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MICHIGAN STATE UNIVERSITY

AGRICULTURAL EXPERIMENT STATION

EAST LANSING

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The Quarterly Bulletin

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THE QUARTERLY BULLETIN

VOLUME 44 • NUMBER 2 • NOVEMBER 1961

MICHIGAN STATE UNIVERSITY
AGRICULTURAL EXPERIMENT STATION
EAST LANSING

L. M. TURK, DIRECTOR
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COSTS AND RETURNS FOR PULPWOOD PRODUCTION IN MICHIGAN[1]

By GORDON D. LEWIS and LEE M. JAMES[2]

DATA FOR THIS ARTICLE were compiled over a 3-year period, 1957 to 1959, from primary and secondary sources. Pulpwood price data were obtained by questionnaire from 10 active Michigan pulp mills and 13 Wisconsin mills drawing wood supplies from Michigan. Cost data were obtained from the pulp mills, the public forest land-owning agencies, and a sample of 38 firms engaged in the marketing of pulpwood. Detailed pulpwood tariff rates were obtained from the major railroad and trucking companies which transport pulpwood to Lower Michigan mills.[3]

PULPWOOD PRICES

Prices for Michigan-produced softwood pulpwood tend to be higher than elsewhere in the nation, while hardwood pulpwood prices are approximately the same in all regions (9). The differences in prices for the same species are due primarily to labor costs and the abundance and accessibility of the timber, although the quality of wood as a source of fiber is also a factor.

Some confusion results from the different practices of pulp companies in quoting prices. Some quote a price which is the middleman's price, although they pay producers $1 less; some quote a middleman's price and pay no other price; some quote the producer's price and pay a 50 cent to $1 bonus to middlemen; while others quote the producer's price, which is the only price they recognize. To remove part of the confusion, all prices referred to in this article are maximum prices.

[1]This article expands and makes more current the analysis of costs and returns in Michigan pulpwood production presented in an earlier report by Lee M. James (Marketing Michigan pulpwood, Mich. Agr. Expt. Sta. Spec. Bul. 411, 1957).

[2]Respectively, assistant professor of forestry, Montana State Univ., and professor of forestry, Michigan State Univ.

[3]The full analysis of transportation costs was published separately. (James, Lee M. and Gordon D. Lewis (1960). Transportation costs to pulpwood shippers in Lower Michigan, Mich. Agr. Expt. Sta. Quart. Bul. 42: 444-469.)

ARTICLE 44-22

Pulp companies purchase wood at several points: delivered at the mill by truck; delivered on board railcars at designated loading points; and, less frequently, stacked in the woods at points which can be reached by truck, or delivered to concentration yards.

Rail-delivered wood is purchased in Michigan at loading points. Prices paid by any mill for a particular species are usually standardized, the same at all points from which a mill will accept delivery. Cost to the mill varies, since transportation costs vary and these are paid by the mill; but usually, the wood price paid to suppliers for a particular species is the same at all rail shipping points.

Truck-delivered wood, with one conspicuous exception, is purchased at the mill yard. Since the pulp companies avoid a rail transportation bill, they pay a price differential for trucked wood delivered to the mill yard.

Table 1 shows the variation in prices paid by pulp mills for rough and peeled wood trucked to the mill (not including differentials for longer hauls) or f.o.b. railcar.

The basic price differential for wood delivered to the pulp mill rather than rail loading points is usually $1.50. In addition, Lower Michigan mills usually pay larger differentials on a sliding scale for pulpwood trucked into the mill yard for distances exceeding specified minimum distances (Table 2). These scales may not fully reflect the increase in hauling costs with greater distances, but they are at least a partial recognition of the actual hauling costs. They stimulate greater use of longer truck hauls in Lower Michigan than elsewhere.

Little price competition is evident (Table 1) among the many Wisconsin and Upper Peninsula mills which tap the Upper Peninsula for wood supplies. The Upper Peninsula mills are largely oriented to local wood supplies. All of the Wisconsin mills reaching into the Upper Peninsula tap the western half; seven of them reach into the eastern half also, but on a diminishing scale as transportation costs come into play (6).

Price competition among Wisconsin and Upper Peninsula mills is even less than is shown in Table 1 because the table shows maximum prices. Average prices at each mill would tend to group more closely. The price differences among companies for any one species is seldom more than $1 or $2. When it is recognized that the maximum price for some companies is the middleman price and for others the producer price, the price differential is even less.

Some differences would be inevitable, even where no price com-

TABLE 1—Maximum prices paid for Michigan-produced pulpwood by Michigan and Wisconsin pulp mills, by species and method of delivery, 1958

Mill number and location	Aspen and white birch				Spruce				Balsam fir				Pine		Hemlock		Miscellaneous hardwoods	
	Rough		Peeled		Rough		Peeled		Rough		Peeled		Rough		Rough		Rough	
	Mill	Rail-car	Mill	Rail-car	Mill	Rail-car	Mill	Rail-car	Mill	Rail-car	Mill	Rail-car	Mill	Rail-car	Mill	Rail-car	Mill	Rail-car
	Dollars per cord																	
Lower Peninsula																		
1	12.00				16.50				16.50				16.50		16.50		13.00	
2	12.50	11.00	18.00	16.00									18.00	16.00	18.00	16.00		
3			17.00															
4	12.00																	
5			22.50	19.50	23.00	28.00			28.00	23.00		28.00						
6			21.00	16.50														
Upper Peninsula																		
7	13.00																	
8			21.50	20.00	29.50	28.00			24.50	23.00								
9			19.50		28.50	27.00			23.50	22.00			18.50					
10			20.50	19.00	29.50	28.00	34.50	33.00	24.50	23.00	29.50	28.00						
Wisconsin																		
11			22.00	20.50	30.00	28.50	35.00	33.50	25.00	23.50	30.00	28.50						
12		13.00		19.00		27.00		32.00		22.00		27.00						
13		13.00		19.00		27.00		32.00		22.00		27.00						
14						27.00		32.00		22.00		27.00				20.00		
15				19.00														
16																		13.00
17						27.00				22.00						19.00		
18				21.00		27.50		32.50		21.00		26.50		18.00		18.00		
19		14.00		21.00		28.00		34.00		24.00		29.00				19.00		
20		14.00		21.00		29.00		34.00		24.00		29.00				19.00		
21			20.50	19.00	29.50	29.00	34.50	33.00	24.50	23.00	29.50	28.00						
22			20.00		28.00				23.00									
23																20.00		

Source: Pulp mill questionnaires.

petition exists, for several reasons. Companies negotiate their contracts at different times and for different lengths of time; companies have varying policies of extending financial and other aids to suppliers, and these aids may partly offset price disadvantages in some cases; pulpwood may be more available in some procurement territories than in others; and, at any given time, price followers lag behind price leaders.

TABLE 2—Sliding price scale additions to the pulpwood base price for longer distances of truck haul used by six Lower Michigan pulp mills, 1958

Distance of haul	Mills					
	A	B	C	D	E	F
Miles	Dollars per cord					
0- 25	....	....	....	....	....	....
26- 50	0.80	....	....	....	0.50	....
51- 75	1.20	0.50	0.50	....	1.00	0.50
76-100	1.60	1.00	1.00	....	1.00	0.50
101-125	2.00	1.50	1.50	1.00	1.50	1.00
126-150	....	....	....	1.00	2.00	1.00
151-175	....	....	....	1.50	2.50	1.50
176-200	....	....	....	1.50	3.00	1.50
Over 200	....	....	....	3.50	3.00	2.00

What role price leadership plays in the price pattern cannot be estimated here, although a number of agents of smaller companies explained that they took their price cues from larger companies.

The larger variations in pulpwood prices in the Lower Peninsula are not linked to competition. Competition among mills for wood supply is, in fact, much less than in the Upper Peninsula. At least two-thirds of the producing area of the Lower Peninsula falls within the procurement territories of single mills or, at best, two mills. No more than a third of the area has, practically speaking, access to three or more mill outlets (6). Because of transportation costs, the producer of a particular species does not often have access to more than one large mill outlet. The price offered by a mill is not strongly influenced by what other buyers may be willing to pay (except that small aspen-using mills must be guided in their price policies by the largest aspen-using mill).

The result of this lack of competition among buyers, as well as some lower production costs, is a generally lower price level in the Lower Peninsula as compared with the Upper Peninsula.

Price variations by species are considerable. They help explain the tendency of pulp mills to increase the proportionate use of aspen and other hardwoods over the old favorites, spruce and balsam fir. The shift would be more pronounced except that the technology of papermaking still requires large amounts of the more expensive pulpwood species to maintain paper quality.

Average Michigan pulpwood prices, f.o.b. railcar, are $27.77 per rough cord for spruce, $22.36 for balsam fir, $18.71 for hemlock, $17.00 for pine, and $13.00 for aspen and the other hardwoods. Peeling increases these prices by an average of $4.90 per cord for spruce, $4.44 for balsam fir, and $6.27 for aspen.

The variations in prices by species are due primarily to the quantity and location of the resource, production costs, and the skill required of producers. For example, spruce production is reaching its maximum allowable cut on public lands and is exceeding it on the more accessible private lands. The remaining stands are more difficult to enter due to the physical aspects of site.

Higher prices are necessary for spruce to encourage the entrepreneur to undertake production, and as pulpwood harvesting on the more difficult sites requires special equipment and ability, the price difference between spruce and the other species is often greater than the actual differences in the costs of production. The average costs of spruce production exceed those of aspen by only $9.03, but the average price received for spruce pulpwood exceeds that for aspen by $14.77.

COSTS OF PRODUCTION

Costs of pulpwood production will be considered separately by the principal categories — stumpage, logging (felling, bucking and skidding), and hauling.

Stumpage

Some buyers and sellers use a rule of thumb in calculating the value of stumpage; this becomes the reference point in individual bargaining situations. Usually, the "rule" states that stumpage is worth 20 percent of the price of delivered pulpwood. Although not scien-

tific, this method sometimes results in a value not far from going market prices of stumpage, at least in parts of the Upper Peninsula.

Most often, however, buyers and sellers determine stumpage values by noting other sale prices in the general market.

In this process, costs of producing stumpage have little effect. Most stumpage is wild or volunteer growth. Landowners have not had costs of soil preparation, planting, protecting and tending of stands. Such costs have been assumed on a large scale by the public agencies in Michigan, but neither the state nor the federal agencies use such costs as a basis for deriving stumpage value.

Private landowners do have holding costs to consider — taxes and interest charges — and such costs would have to be covered in the long run for owners to remain in the stumpage-selling business. Nevertheless, this aspect of cost coverage has had little influence on stumpage prices. It has been pointed out that when the great bulk of timber is produced with conscious effort and cost, stumpage price will have to cover costs of production or stumpage will not be grown (7). However, this stage has not yet been reached.

The usual assumption is that stumpage value is derived from "conversion return", which is the residual between the selling price of products and the costs of logging and hauling (7, 1). The "conversion return" includes both profit allowance (an estimated margin for profit, risk, interest on borrowed capital, and income taxes) and stumpage value. Imperfect knowledge on the part of both buyer and seller results in widely varying estimates of conversion return. Unequal bargaining abilities and local precedent result in different apportionments of conversion return into stumpage value and profit allowance.

Stumpage prices would vary greatly simply as a result of the abilities of buyers and sellers to estimate conversion return and to break it down into stumpage value and profit allowance. An even more compelling influence is the infinite variation in forest conditions — species composition, volume per acre, size and quality of trees, location, accessibility, topography, and the costs of conversion.

Thus, we find sale prices in the state forests of the Upper Peninsula ranging from $1.00 to $5.00 per cord in balsam fir, $2.00 to $8.75 in spruce, and $0.35 to $2.50 in miscellaneous hardwoods (Table 3).

Average stumpage prices are listed separately for the Upper Peninsula and the Lower Peninsula by species and major landowning groups in Table 4.

TABLE 3—Range of stumpage prices on state forests in Michigan, by species, 1958

Species	Upper Peninsula	Lower Peninsula
	Dollars per cord	
Aspen	1.00-3.00	0.75-1.40
Pine	1.50-4.00	1.00-4.00
Balsam fir	1.00-5.00	1.50-4.00
Spruce	2.00-8.75	1.75-5.00
Hemlock	1.50-3.00	.....
Miscellaneous hardwoods	0.35-2.50	0.50-1.50

Source: Division of Forestry, Michigan Department of Conservation, Lansing.

Prices for the major pulpwood species — aspen, balsam fir and spruce — tend to be higher in the Upper Peninsula than in the Lower Peninsula. This geographic differential should be expected since competition for available spruce, fir and aspen is usually keener in the Upper Peninsula, and delivered pulpwood usually commands a higher price. In contrast, the market for pine is much greater in Lower Michigan; hence, pine prices are higher here than in Upper Michigan.

The contrasts in stumpage prices by landowning agencies are less easily described. State forest stumpage tends to be lower in price than national forest stumpage in Upper Michigan and substantially

TABLE 4—Average pulpwood stumpage prices received by public and private forest landowners in Michigan, by species, 1958

Forest landowners	Aspen	Pine	Balsam fir	Spruce	Hemlock	Miscellaneous hardwoods
	Dollars per cord					
Upper Peninsula:						
Federal	2.35	2.75	4.39	7.63	2.70	0.50
State	2.34	2.59	4.33	7.21	3.00	0.66
Private	1.37	....	4.50	7.75	....	2.50
Lower Peninsula:						
Federal	1.62	3.48	3.65	6.17	....	1.13
State	1.23	2.62	3.16	4.07	....	0.82
Private	1.25	3.25	4.13	6.75	....	2.25

Source: Federal prices from the supervisors of the national forests, U.S. Forest Service; state prices from the Forestry Division, Michigan Department of Conservation, Lansing; and private prices from pulp company, middleman, and producer questionnaires.

lower in Lower Michigan. Private stumpage, with the notable exception of aspen, tends to be higher priced than public stumpage in both peninsulas.

There is a strong presumption that public agencies, which were the source of 43 percent of the pulpwood produced in 1958, tend to set the price pattern. This role is exerted mainly by the national forests. State policy generally avoids setting stumpage prices on the basis of conversion return calculations because of a philosophy that private market prices should control public prices. Nevertheless, a seller as large as the state cannot fail to have some effect on the stumpage market.

Stumpage appraisals by the U. S. Forest Service are based on conversion return calculations. Starting with the sale price of delivered pulpwood, the Forest Service estimates the costs of logging and hauling. Part of the margin between costs of logging and hauling and sale price is set aside as the proper allowance for profit and risk in the production process; what is left is stumpage value. This calculated stumpage value is the price insisted on in negotiated sales, and it is the lowest acceptable price in cases where stumpage is sold on bid.

The effect of the Forest Service method on the price levels of the stumpage market cannot be determined here. However, a strong influence on private sales can be presumed from the large volume of pulpwood involved, the wide geographic spread in sales locations, and the publishing of sales prices. To the extent that an influence is exerted, the method of calculation is important. Since stumpage value is determined from the margin between typical costs of production and pulpwood sale price, adding stumpage to the other costs of production will result in a total which is not higher than the sale price.

The discussion of stumpage prices has been in terms of rough timber, but an adjustment is needed to apply to peeled pulpwood operations. It takes more trees to make a cord of peeled wood than a cord of rough wood.[4] This fact is recognized by the public agencies and other sellers who base stumpage charges on the scaled volume of pulpwood stacked before removal from the woods. A cord of peeled pulpwood may represent 1.15 cords of rough pulpwood, and the stumpage charge is adjusted accordingly.

In general, stumpage costs to pulpwood producers are about 15

[4]A standard cord is based upon pulp sticks 8 feet long stacked in ricks 4 feet wide and 4 feet high (8x4x4=128 cubic feet). Its solid content varies greatly with the thickness of the bark, the size of the sticks, the methods of piling, and the straightness and smoothness of sticks. The solid wood content of a cord is estimated at about 85 cubic feet for softwoods, 80 cubic feet for hardwoods (2). Bark accounts for 16 to 17 cubic feet in a standard cord of rough wood.

percent greater per cord of peeled wood than they are per cord of rough wood. This higher scale of stumpage costs is presented in Table 5.

TABLE 5—Average peeled pulpwood stumpage costs to Michigan pulpwood producers, by species and landowner sources of wood, 1958

Landowner source	Aspen	Pine	Balsam fir	Spruce	Hemlock	Miscellaneous hardwoods
	Dollars per cord					
Upper Peninsula:						
Federal.....	2.70	3.13	5.05	8.77	3.16	0.58
State.....	2.69	2.98	4.95	8.30	3.45	0.76
Private.....	1.58	....	5.17	8.91	....	2.88
Lower Peninsula:						
Federal.....	1.86	4.00	4.20	7.10	....	1.30
State.....	1.42	3.01	3.61	4.68	....	0.94
Private.....	1.44	3.75	4.75	7.76	....	2.59

Source: Rough pulpwood prices in Table 4 increased by 15 percent.

Logging Costs

Logging, as used here, includes felling and bucking, bark peeling (when this is done), and skidding to roadside. The whole production process, from standing tree to roadside, may be handled as a single operation; in that case, costs are figured for the entire operation. Usually, felling and bucking is considered a distinct operation, and costs are separate from skidding costs.

The U. S. Forest Service (8) has analyzed logging costs as a basis for stumpage appraisal in numerous operations on the national forests and surrounding areas. These are the costs which have been summarized in Table 6.

Felling and bucking costs are often paid for on a piece basis. These rates — usually $0.08 to $0.12 per piece — have been converted to cost per cord to compare with other costs figured on a cord basis. Felling and bucking costs are highest in spruce and fir. They average $1.50 to $2.00 less per cord in pine and about $3.00 less in aspen. The averages conceal wide variations in costs for any given species. Such cost differences can be expected because of wide differences in pulpwood stands — differences in working conditions, number and size of merchantable trees, tree taper, limbiness, stand density, species composition, tree quality, volume per acre, and total volume in the stand.

Peeling costs are incurred mainly in aspen production, although there is some demand for peeled pulpwood of other species. On the average, peeling costs $2.79 per cord for aspen (ranging from $2.00 to $5.00) and $4.63 for spruce and balsam fir.[5]

Skidding costs vary by type of equipment used, distance of skid, size and spacing of timber cut, and topography. Species, as such, has little influence on the costs. Skidding costs average $3.06 per cord in the Upper Peninsula (ranging from $1.50 to $4.50) and $3.61 per cord in the Lower Peninsula (ranging from $1.50 to $6.20).

Other costs of logging are primarily those connected with the development of the area to be logged and overhead costs. Development costs consist largely of road construction. Occasionally, in the Upper Peninsula, logging camp construction is also involved. Extensive road construction may be necessary on the larger operations and often represents a cost of more than $1.00 per cord. On the smaller operations, road construction is held to a minimum by lengthening skidding distances and using drays.

Overhead costs, mainly for supervision, increase with the size of

[5]A contract peeler using a portable debarker may charge $4.00 per cord for debarking. Assuming costs of $1.00 for machine mortgage payments, $1.00 for machine operation (3) and $1.75 for labor, the likely margin for profit and risk is $0.25. However, since most mills pay approximately $5.00 per cord more for peeled than for rough pulpwood, the operator's margin may be increased to $1.25 per cord.

TABLE 6—National forest estimates of average logging costs incurred in producing pulpwood in Michigan, 1958

Costs	Spruce		Balsam fir		Aspen		Pine	Miscellaneous hardwoods
	Peeled	Rough	Peeled	Rough	Peeled	Rough		
	Dollars per cord							
Lower Peninsula:								
Felling and bucking	5.32(*a*)	6.36	6.35(*a*)	6.42	3.50	3.35	4.45	3.00
Peeling	4.25	....	4.25	....	3.50	....	....	....
Skidding	6.18	5.13	5.15	5.08	1.80	1.72	2.32	1.50
Other costs	0.82	0.82	0.82	0.82	0.82	0.68	0.95	0.50
Total	16.57	12.31	16.57	12.32	9.62	5.75	7.72	5.00
Upper Peninsula:								
Felling and bucking	6.41(*a*)	6.53	5.47(*a*)	6.53	3.64	3.47	4.98	3.00
Peeling	5.58	....	4.44	....	2.08	....	....	....
Skidding	2.76	3.48	2.76	3.48	3.28	2.42	2.76	1.50
Other costs	1.30	2.75	1.30	2.75	2.37	2.45	2.22	0.50
Total	16.05	12.76	13.97	12.76	11.37	8.34	9.96	5.00

(*a*) Lower felling and bucking costs for peeled spruce and fir than for rough wood of these species can only be explained on the basis of inadequate sampling of peeled wood operations. Other factors being equal, felling and bucking costs will be higher per cord for peeled wood operations, since more trees are required to make a cord of peeled wood than of rough wood.

Source: U. S. Forest Service (1959). *Handbook on Timber Appraisal,* Temporary Directive. U. S. Forest Service, Milwaukee, 46 pp.

operation. The typical 1- and 2-man operations of the Lower Peninsula may, in fact, have no supervision cost. In the Upper Peninsula, where the pulpwood logging chances are more difficult to operate, overhead costs range from $1.16 to $2.33 and average $1.79 per cord. In the Lower Peninsula, they range from $0.68 to $0.90 and average $0.81 per cord.

Pulp company estimates of logging costs (Table 7) vary from those of the Forest Service. The total estimates are fairly close in the Upper Peninsula, but in the Lower Peninsula, substantial differences appear. The company estimates total more for aspen, less for pine and considerably less for spruce and fir. There is little consistency in the treatment of individual cost items except that the reporting mills almost invariably assumed lower development and overhead costs and higher costs for peeling than did the Forest Service.

TABLE 7—Pulp company estimates of average logging costs incurred in producing pulpwood in Michigan, 1959

Costs	Spruce		Balsam fir		Aspen		Pine
	Peeled	Rough	Peeled	Rough	Peeled	Rough	
	Dollars per cord						
Lower Peninsula:							
Felling and bucking	4.00		4.00		3.17		
Peeling	5.00		5.00		4.83		
Skidding	3.00		3.00		2.33		
Other costs	....		....		....		
Total	12.00		12.00		10.33		
Upper Peninsula:							
Felling and bucking		8.60		8.60	6.00	3.00	
Peeling		....		..		....	
Skidding		3.00		3.00	3.00	3.00	
Other costs		1.00		1.00	1.00	1.50	
Total		12.60		12.60	12.00	7.50	

Hauling Costs

Hauling, as used here, refers to truck haul from roadside points in the woods to railroad loading points or to pulp mills.[6] Hauling is

[6]Railroad transportation is not considered here because the cost is assumed by the pulp companies and does not comprise a part of the suppliers' costs of production. An analysis of pulpwood hauling costs by rail and by truck to indicate the comparative advantages and disadvantages of the two methods of transportation, both from the viewpoints of suppliers and pulp mills, was reported separately (5).

the responsibility of the pulpwood seller since, with one exception,[7] pulp companies accept wood only on the railcar or at the pulp mill.

Distance of haul to pulp mills is highly variable, depending on access to mills and company policy in encouraging longer truck hauls. In the Upper Peninsula, truck hauls exceeding 60 to 70 miles are generally avoided; if longer distances to mills are involved, pulpwood is usually delivered to rail loading points. Long truck hauls occur only in the Lower Peninsula where they are encouraged by sliding price scales. Median hauling distances in Lower Michigan are 200 miles for spruce and fir and 70 miles for peeled aspen going to one mill, 90 miles for rough aspen and pine to another, 60 miles for all species to a third mill, and 100 miles for all species to other mills.

Distance of haul to rail loading points is much more limited. Short hauls to railcar are usually 5 to 10 miles while the long hauls rarely exceed 30 miles; the median distance is 15 miles.

Hauling costs commonly range from a fifth to more than a third of the total costs of pulpwood production. Their magnitude and range frequently become the determining factor in the decision to produce pulpwood from a given locality or stand.

Dealers and producers haul pulpwood when they have their own trucks, but usually, pulpwood hauling is contracted out to independent haulers at a stated rate per unit of volume. Rates vary, depending on distance, road conditions, bargaining abilities, and rate patterns set within localities.

The minimum charge for truck hauling is usually $3 per cord, although sometimes a $2.50 charge turns up. The maximum, for a hauling distance of 250 miles, is $12. Charges are usually established for distance zones: For example, a contractor may charge a fixed amount for distances up to say, 15 miles; a higher charge for distances from 16 to 35 miles; and, still higher charges for greater distances.

For distances under 75 miles, contracts are usually negotiated between small truckers and producers or dealers. Individual negotiations also apply to many of the longer hauls, but the prevailing practice in Lower Michigan, where the longer hauls apply, is to follow a schedule set up by formula between the largest pulpwood-buying mill and its chief contract carrier. In this schedule, the following formula rates apply:

[7]One Michigan mill purchases wood roadside at distances beyond 75 miles from the mill and assumes responsibility for truck transportation. When such purchases are made, the price paid is $4.00 per cord less for aspen and $5.50 per cord less for pine and hemlock than is paid for wood purchased f.o.b. railcar.

Distance (miles)	Rate per mile per cord (dollars)
100 or less	0.065
100 to 150	0.055
Over 150	0.049

Truck-hauling charges to pulp mills may now be summarized by distances (Table 8). Negotiated contracts begin at $3 per cord for minimum hauls under 10 miles and rise, on the average, to $4 at 20 miles, to $5 at 40 miles, and to $6 at 90 miles. Formula rates calculate to $4.87 per cord at 75 miles (the usual minimum distance to which formula rates apply), $6.50 at 100 miles, $8.25 at 150 miles, $9.80 at 200 miles, and $12.30 at 250 miles.

TABLE 8—Average contract truck-hauling charges for direct deliveries to pulp mills, by distance of haul, 1957

Distance	Average charge per cord	Distance	Average charge per cord
Miles	Dollars	Miles	Dollars
10	3.00	140	7.70
20	4.00	150	8.20
30	4.50	160	8.20
40	5.00	170	8.40
50	5.00	180	8.80
60	5.00	190	9.30
70	5.50	200	9.80
80	5.50	210	10.30
90	6.00	220	10.80
100	6.25	230	11.30
110	6.25	240	11.80
120	6.60	250	12.30
130	7.20		

Where hauling is to railcar rather than to the pulp mill, an average of $1 should be added to the rates shown in Table 8 to cover the additional unloading and loading necessary to place pulpwood on railroad cars.[8]

The rates presented here are average contract charges which may

[8]Unloading trucks or freight cars at the mill yard is the pulp company's responsibility. All other loading and unloading at earlier stages in the marketing chain are the supplier's responsibility. In the case of direct truck delivery from the woods, the supplier needs to load only once. In the case of railroad delivery, the supplier has to load the truck, unload it at the rail siding and load again onto railroad cars. Handling costs to shippers are accordingly greater in rail haul than in direct truck haul.

differ from the actual costs of truckers. It has been pointed out previously that many small truckers do not understand the nature of fixed costs and often underestimate their actual costs of operation. When their equipment needs to be replaced, they may discover that contract charges do not cover total costs. In the latter event, they may return to wage-earning occupations and their enterprises are taken over by new recruits eager to move from the wage earner to the contractor role (4).

COMPARISON OF COSTS AND PRICES

A comparison of costs of production with delivered pulpwood prices is attempted in Table 9. The data should be interpreted with caution because of the special conditions reflected therein (including the averaging of widely different price and cost data). The prices shown are f.o.b. railcar; they would be at least $1.50 higher for pulpwood delivered directly to the mill. Costs are imputed in all operations, but frequently the operator uses his own stumpage or his own labor and equipment in logging and hauling; his out-of-pocket expenses are low and he may impute much lower costs than are required by contract operations. On the other hand, the assumptions of $4.25 and $4.50 hauling costs are at the lower end of the hauling cost scale; true averages would probably be somewhat higher.

The margins between total costs of production and selling price should not be examined for specific magnitudes, but in a general way they express the relative profitability of handling different species. Margins in the Upper Peninsula are greatest in peeled fir and spruce; they average less than $1 in rough fir and rough aspen and are slightly negative in rough pine. Margins are generally higher in the Lower Peninsula except for peeled fir and rough aspen (which is negative). In the latter instance, it should be recalled that the usual pattern of direct-to-mill deliveries, involving sliding scale additions to price, would make the margin for rough aspen positive. Nevertheless, rough aspen is typically the least profitable pulpwood species to produce in Lower Michigan as rough pine is clearly the least profitable in Upper Michigan.

The last column in Table 9 expresses the profit margin as a percentage of the price received for delivered wood. This measure of profitability — termed profit ratio — is often considered a more revealing measure of profits than is the absolute margin (10).

TABLE 9—Margins and profit ratios for the production of Michigan pulpwood delivered on railroad cars from a hauling distance of 30 miles

Species	Price received	Stumpage cost	Logging cost	Hauling cost	Margin	Profit ratio(a)
	Dollars per cord					Percent
	LOWER PENINSULA					
Spruce						
Rough	28.00	5.66	12.32	4.25	5.77	20.6
Peeled	33.00	6.51	16.57	4.25	5.67	17.2
Balsam fir						
Rough	23.00	3.65	12.32	4.25	2.78	12.1
Peeled	28.00	4.20	16.57	4.25	2.98	10.6
Aspen						
Rough	11.00	1.37	5.75	4.25	−0.37	....
Peeled	17.33	1.58	9.62	4.25	1.88	10.8
Pine	16.00	3.12	7.72	4.25	0.91	5.7
Miscellaneous hardwoods	13.00	1.40	5.00	4.25	2.35	18.1
	UPPER PENINSULA					
Spruce						
Rough	27.75	7.53	12.76	4.50	2.96	10.7
Peeled	32.66	8.53	16.05	4.50	3.58	10.9
Balsam fir						
Rough	22.63	4.41	12.76	4.50	0.96	4.2
Peeled	27.50	5.07	13.97	4.50	3.96	14.4
Aspen						
Rough	14.00	2.02	8.34	4.50	0.86	6.2
Peeled	19.85	2.32	11.37	4.50	1.66	8.4
Pine	17.00	2.67	9.96	4.50	−0.13	....
Miscellaneous hardwoods	13.00	1.22	5.00	4.50	2.28	17.4

(a) Profit ratio is the ratio of the margin to price received.

Regionally, it is difficult to generalize about profit ratios other than to state that they are much higher for Lower Peninsula spruce than for Upper Peninsula spruce. Profit ratios are higher in the Lower Peninsula for rough fir, peeled aspen, and rough pine; they are lower for peeled fir and rough aspen; they are about the same for miscellaneous hardwoods.

In contrasting peeled wood and rough wood operations, it is evident that peeling results in a substantially improved profit ratio only in the case of aspen in Lower Michigan and balsam fir in Upper Michigan. In other instances, peeling does not appear to offer any significant advantage to the producer.

In general, pulpwood operations in Michigan appear to be profitable. Under the assumptions of this analysis, most pulpwood operations (with the notable exception of rough aspen in Lower Michigan and rough pine in Upper Michigan) yield a positive profit margin and a satisfactory profit ratio.

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CHEMICAL CONTROL OF KENTUCKY BLUEGRASS LEAFSPOT CAUSED BY *HELMINTHOSPORIUM VAGANS*

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Leafspot of common kentucky bluegrass, caused by *Helminthosporium vagans* Drechs. (3) is found throughout the United States (5) in lawns and pastures. It is most injurious in the northeastern states (6). Cool, damp weather is conducive to maximum development.

The disease appears as minute water-soaked lesions on the leaves (1, 2). These enlarge and darken. As the lesions enlarge further, the centers become lighter in color even to a straw-white shade. The disease can extend internally to the sheath, crown and roots. Thus, it assumes its most destructive form in home lawns and farm fields.

MATERIALS AND METHODS

An established home lawn, which was seeded to straight Kentucky bluegrass in 1955, was found to be heavily and evenly infected with *Helminthosporium vagans* Drechs. Subsequent investigation disclosed a high incidence of nematodes, notably the ectoparasitic Tylenchorhynchus. sp.[1]

Four fungicides (Table 1) were tested for control of this fungus on randomized plots 12½ by 40 feet, replicated three times. An appropriate amount of chemical was placed in 7½ gallons of well water. This mixture was sprayed with a garden sprayer equipped with a hand gun adjusted to a fine mist. Operating pressure was about 175 pounds per square inch. Plots were sprayed on May 4, 10 and 17, 1961. Disease incidence was recorded on May 16 and 22, 1961. Stems were collected and observations made of the number of plants, expressed in percentage, with terminal and/or first lateral leaf exhibiting symptoms of leafspot.

[1]Identification was made by John Knierim, nematologist, department of entomology.

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TABLE 1—Composition and rates of fungicides used in treating Kentucky Bluegrass leafspot

Trade name	Formulator	Content	Rate used per 1,000 sq. ft.
Acti-dione RZ	The Upjohn Company Kalamazoo, Mich.	Cycloheximide..... 1.3% Pentachloronitro-benzene.....75.0% Inert ingredients.....23.7%	1½ oz.
Acti-dione Thiram	The Upjohn Company Kalamazoo, Michigan	Cycloheximide..... 0.75% Thiram.....75.0% Inert ingredients.....24.25%	3½ oz.
Dyrene	Chemagro Corp.	2,4-dichoro-6-o-chlora-nilino-s-triazine.....50% Inert ingredients.....50%	8 oz.
Panogen Turf Spray	Panogen Co. Div. of Morton Chemical Chicago, Ill.	Methylmercury dicyan-diamide..... 2.2% Inert ingredients.....97.8%	3 fl. oz.

RESULTS

The average percentage of plants with lesions on the terminal and/or next lower leaf after two applications is presented in Table 2 and after three applications in Table 3.

DISCUSSION

All chemicals tested resulted in a significant reduction in the number of plants with foliar symptoms of leafspot upon the upper-

TABLE 2—Percentage of plants showing leafspot symptoms, average of three replicates, May 16, 1961

Treatment	Percentage	Duncan Rating*
Acti-dione RZ.....	23	a
Acti-dione Thiram.....	32	ab
Dyrene.....	35	b
Panogen.....	51	
Check.....	80	

*Treatments with the same letter are not significantly different from each other at 5% level (4).

TABLE 3—Percentage of plants showing leaf-spot symptoms, average of three replicates, May 22, 1961

Treatment	Percentage	Duncan Rating*
Acti-dione Thiram	25	a
Dyrene	39	ab
Acti-dione RZ	41	ab
Panogen	49	b
Check	78	

*Treatments with the same letter are not significantly different from each other at 5% level (4).

most two leaves. This occurred after two as well as after three applications. After two applications, Acti-dione RZ treated plots possessed significantly fewer visibly infected leaves than Dyrene and Panogen sprayed plots but did not differ significantly from the Acti-dione Thiram treated plots. The latter varied only from the Panogen and check plots. After three applications, neither Acti-dione RZ nor Dyrene was significantly different in action from any other chemicals. Acti-dione Thiram was significantly better in disease control than Panogen.

All treatments were superior to the no-treatment check. The presence of nematodes may have reduced the effectiveness of these control measures so that there still remained 23 or 25 percent of the plants infected.

SUMMARY AND CONCLUSIONS

Acti-dione RZ, Acti-dione Thiram, Dyrene and Panogen each resulted in a reduced number of plants with foliar lesions of *H. vagans* on the uppermost two leaves. Panogen was not as effective as Acti-dione Thiram.

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THE EFFECT OF APPLES ON THE GENERAL HEALTH OF COLLEGE STUDENTS[1, 2, 3]

By R. R. DEDOLPH, J. A. STEVENS, R. N. MONFORT, and H. B. TUKEY

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INTRODUCTION

Folklore has long attributed health-giving properties to apples. Many workers have shown that apples in the diet may benefit individuals suffering from diverse maladies, including edema (5), dental caries (8), intestinal disorders (1, 3, 4, 8), and hypertensive disorders (6), as well as counteracting the toxic effects of lead (7). This study was undertaken to evaluate the effect of regular apple consumption on the general health of college students. The maxim, "An apple a day keeps the doctor away", has been substantiated to some degree.

MATERIALS AND METHODS

For three consecutive years, 500 volunteers were solicited from students registering at Michigan State University to participate in this experiment. The volunteers were accepted solely on a basis of willingness to participate. No other criteria such as sex, past medical history, or general health were considered. Roommates of the volunteers, however, were encouraged to participate so as to decrease the possibility of fruit being shared by non-participants.

At the beginning of the first experimental period, participants were supplied with three apples per day; they were permitted to lower their consumption to a constant one of two fruits daily, if the lower rate better suited their appetite.

In the second and third experimental periods, all participants consumed two apples daily. Each experimental period covered the

[1]This manuscript was prepared from notes and data taken by Dr. E. H. Lucas prior to his untimely death, January 28, 1959. It was Dr. Lucas who outlined and directed the work here reported.

[2]The helpful assistance and cooperation of the staff of the University Health Service, Michigan State University, is gratefully acknowledged.

[3]This work was supported in part by grants from the National Apple Institute, Washington, D.C. and the Michigan State Apple Commission, East Lansing, Michigan.

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first two 10-week terms of the school year. Participants were allowed to choose Cortland and or McIntosh fruits during the first term and Delicious and or Golden Delicious during the second term of each experimental period. All fruit supplied students was of excellent quality and "eating ripe".

At the end of each experimental period, the University Health Service record of each student who had participated throughout the entire period was examined. The cause of each visit to the clinic was categorized as one of the following: upper respiratory infections, skin disorders, gastro-intestinal disorders, tension-pressure phenomena, mononucleosis, eye and ear disorders, genitalurinary infections, menstrual disorders, non-specific supportive disorders, mouth infections, blood disorders, hayfever and asthma, other allergies, circulatory disorders, metabolic disorders, epilepsy, and nervous system disorders (viral). Since university students pay only a nominal charge for drugs and medications, but are not charged for professional advice and diagnosis, they readily report to the clinic for treatment.

The control group numbered 17,176, 17,934 and 17,504 for the first, second and third period, respectively, for a total of 52,614. The active participants numbered 433, 488, and 400 for the same periods, totaling 1,381.

The nature of the evaluation, the frequency of clinic calls among the participants and non-participants for this or that malady, suggests the use of a Chi Square test.

In applying this test to these data, the expected frequency used was the average frequency of clinic calls of the entire student body. In comparisons of frequency of calls for individual maladies, many categories showed five or fewer calls among the total student body and none in the participant group during one or more experimental periods. Where the incidence of the malady was ludicrously low, it was dropped from individual consideration, as it was felt that such low incidences were not valid estimates of general trends.

In all cases, the data showing significance on a yearly basis were further tested by pooling the data from three years to establish the general trend. In no case have data been purported to show differences where the differences in any one period have not been borne out when the three periods were pooled. The statistical problems involved are thus easily resolved.

The biological implications of these data are not as easily resolved.

The participants were a group of individuals who liked apples; thus, the implications derived from these data may well be tempered by the general dietary habits of the volunteers.

RESULTS AND DISCUSSION

During the three experimental periods, 66 percent of the calls at the Health Service were made for two types of disorders; namely, upper-respiratory infections and tension-pressure phenomena. Fifty percent were for the former and 16 percent for the latter. Over the 3-year period, the participants made fully one-third fewer calls for upper-respiratory infections than would be expected from behavior of the student body as a whole. The advantage ranged from about 27 percent fewer in the first year to 37 percent fewer during the last year. This may possibly be a reflection of benefit from the consistent supplementary ascorbic acid obtained from the apples in the diet.

Differences in number of clinic calls made by the two groups for tension-pressure phenomena were even more striking. The 3-year trend showed that the participants made less than one-sixth as many calls as would be expected on a basis of the behavior of the student body as a whole. The advantage in this malady ranged from 75 percent fewer in the third year to 93 percent fewer in the second year. These increases may be due to the type of individual participating, the better balanced diet resulting from apple consumption, or perhaps to some naturally occurring tranquilizer in the apple fruit.

The remaining 15 categories accounted for 34 percent of the calls. In some instances, as mentioned above, the total incidence was so low as to make a comparison for those specific categories not feasible. In other categories, although the 3-year average may have been significantly lower, this trend was not uniform for the separate experimental periods.

When all categories except upper-respiratory infections and tension-pressure phenomena are considered (Table 1), two of the three periods, as well as the 3-year totals, indicate the participants made significantly fewer clinic calls for these categories. Although not as conclusive as the comparisons for the first two maladies, these data would indicate that the general health of the participants, as measured by clinical calls, was somewhat better than the general health of the entire student body, even excluding the upper-respiratory and tension-pressure phenomena disorders.

TABLE 1—Average number of clinic calls per individual

Malady	Period	Entire student body	Participants
Upper-respiratory infections	1956-57	0.33	0.24(*a*)
	1957-58	0.51	0.35(*a*)
	1958-59	0.40	0.25(*a*)
	3 years	0.42	0.28(*a*)
Tension-pressure phenomena	1956-57	0.13	0.01(*a*)
	1957-58	0.14	0.01(*a*)
	1958-59	0.12	0.03(*a*)
	3 years	0.13	0.02(*a*)
All other maladies	1956-57	0.26	0.17(*a*)
	1957-58	0.22	0.18
	1958-59	0.38	0.21(*a*)
	3 years	0.28	0.19(*a*)

(*a*) Average number of calls is lower than the expected average at odds of 99:1.

SUMMARY

Students who volunteered to eat apples during the first and second quarters of 3 successive academic years made significantly fewer calls at the University Health Service clinic during the experimental periods for treatment of upper respiratory disorders and tension-pressure phenomena than would be expected on a basis of the entire student body. The upper-respiratory and tension-pressure phenomena disorders accounted for two-thirds of the clinic calls.

Over the three experimental periods, the students who volunteered likewise showed better general health as indexed by number of clinic calls for ailments other than upper-respiratory and tension-pressure phenomena than did the student body in general during the same periods. Though the second year of experiment showed no significant advantage for the volunteers in these less common maladies, both first and third periods showed marked benefit to the volunteers as did the three period totals.

The health of the apple-eating volunteers was thus shown to be generally better than that of the student body as a whole, as indexed by clinic calls made during the experimental periods.

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THE EFFECT OF VELOCITY OF STEAM-AIR MIXTURES ON THE HEATING OF GLASS CONTAINERS

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STEAM-AIR MIXTURES at near zero velocity were found by Pflug and Nicholas (7) to be less efficient when used to heat containers of water than either a water bath, water spray or saturated steam. The wide usage of steam-air mixtures in pickle pasteurizers stimulated further work to ascertain the cause of this decreased efficiency. This investigation was undertaken to determine the effect of the velocity of steam-air mixtures on the heating characteristics of water in glass containers.

EXPERIMENTAL METHOD

All tests were conducted using 16-oz. (303) glass jars with lug closure: outside diameter 3.12 in.; height to finish 4.25 in.; overflow capacity 16.5 oz.; fill 16 oz. of distilled water.

The apparatus used in this experiment is shown in Fig. 1. It consisted of a laboratory retort modified by the insertion of an inverted tank with a 10 in. length of 6⅛ in. I.D. pipe, welded in place. The test jar was centered in this pipe by sharpened screws and rested on a strand of 0.020 in. O.D. steel wire stretched across the pipe.

The heating control system is also shown in Fig. 1. The air flow rate was measured by a rotameter and maintained constant by manual control. Steam flow to the system was maintained by a proportioning temperature control system. The sensing thermocouple was located below the jar in the entrance to the pipe and adjacent to the retort temperature measuring thermocouple. The air and steam entered the retort through ports in a four-armed cross at the bottom of the retort. These ports were at right angles to the retort diameter and at a 45° angle from the bottom and imparted a swirling motion to the mixed gases.

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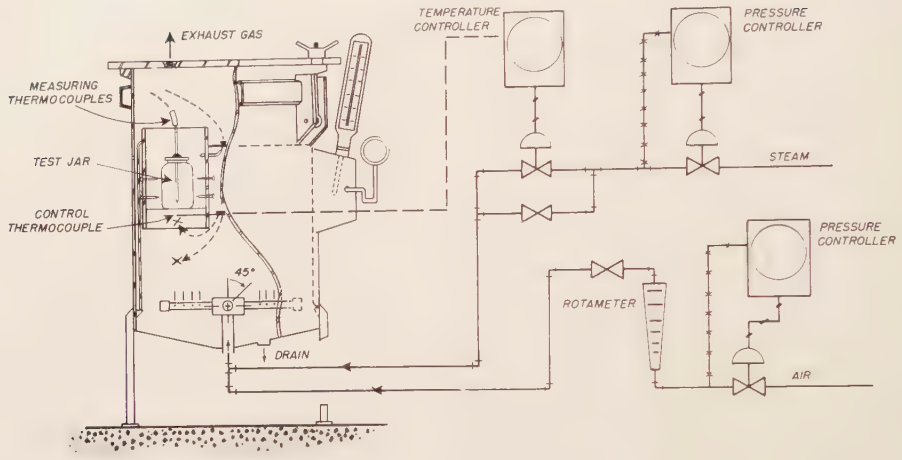

Fig. 1. Schematic diagram of modified laboratory retort and the heating control system.

The lid to the retort was loosely closed during the tests in order to eliminate the various chimney effects that were observed in the systems used in preliminary studies. The retort system was allowed to equilibrate at the test temperatures before each test was started. This procedure and the use of the inner chamber eliminated come-up-time corrections. In some tests the heat load of the retort system was further reduced by insulating the retort with a 2-in. thickness of fiber glass insulation.

The temperatures in the jar were measured with 24-gage copper-constantan thermocouples similar to those used by Pflug and Nicholas (7). The thermocouple junctions were located in the vicinity of the slowest heating point; namely 0.32 in. (0.8 cm.) above the inside bottom of the jar. The steam-air mixture temperatures were measured both above and below the jar and at several other points in the apparatus. Temperatures were measured and recorded by a 12-point (1 min. cycle) temperature recording potentiometer; the smallest chart division was 1°F.

The gas at the control point thermocouple was assumed saturated with water vapor (steam) and to behave as an ideal solution; therefore,

$$\frac{V_s}{V_t} = \frac{V_t - V_a}{V_t} = \frac{P_s}{P_t} = \lambda$$

where

P_s = partial pressure of steam (2)
P_t = partial pressure of system, one atmosphere here
V_a = volume of air
V_s = volume of steam
V_t = total volume

hence

$$V_t = V_a/(1-\lambda).$$

The volume rate of flow was measured by a rotameter and corrected to retort temperature using the ideal gas law. Appropriate corrections were made for temperature and pressure of the gas at the rotameter (3). This flow was substituted in the above relation to obtain the total gas volume flow rate. This latter flow rate was divided by the calculated annular area between jar and pipe to give the mean annular velocity. Mean annular velocities from near zero to over 8 feet per second were studied.

The initial temperatures of the water in the jars was 95.6 ± 1°F. Three steam-air mixture temperatures were studied; 165, 180 and 195°F. The mean variation in retort temperature within runs was ± 0.5°F.; among runs was ± 1.0°F. for the uninsulated series. The variation for the insulated series was approximately twice as much due to the decreased heating load on the control system.

The heating data were analyzed by plotting the temperature difference between product and heating medium vs. time on semi-logarithmic paper according to the conventional method described by Ball and Olson (1). These curves were found to approach a straight line. The f_h and j were then determined for the linear portion of the graph.

RESULT AND DISCUSSION

The results, in terms of the effect of the velocity of steam-air mixture on the heating parameters f_h and j of pint jars of water, are shown graphically in Figs. 2 and 3. The results may be summarized as follows: (1) f_h decreased (faster heating) with increasing velocity; (2) f_h at near zero velocities increased when the system was insulated; (3) f_h decreased with increasing heating medium temperature; (4) the average lag factors j for all tests was 1.34.

The efficiency of steam-air mixtures at low velocities is very poor — note large f_h values in Fig. 3; however, their efficiency at high ve-

Fig. 2. Scatter diagram of heating rate parameters f_h and j.

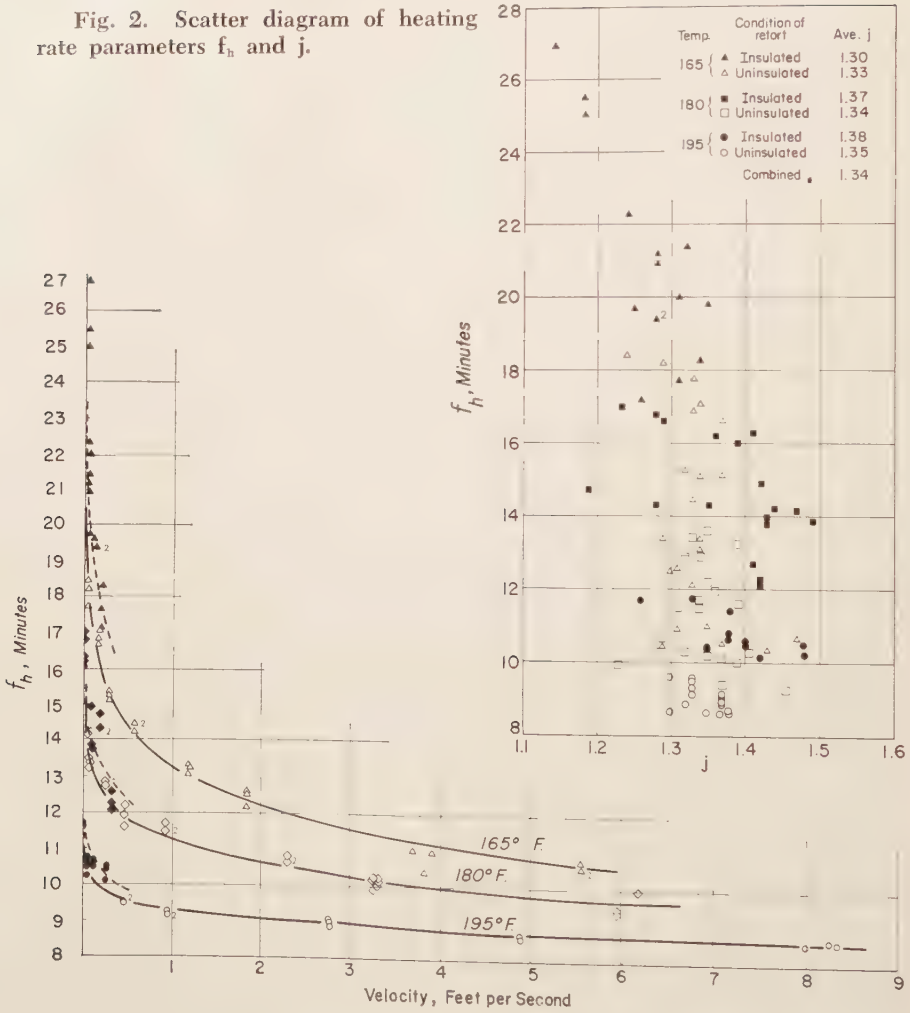

Fig. 3. Heating rate parameter (f_h) of pint jars of water as a function of velocity of steam-air mixtures at atmospheric pressure.

locities is very good, as shown in Table 1, where the f_h of steam-air at the maximum velocity tested are compared to the f_h values Pflug and Nicholas (7) obtained using a water spray. These comparisons point out that at the same temperature heating with steam-air mixtures is nearly as effective as water spray only provided the velocity of the steam-air mixture is sufficiently high.

The heating characteristics of pint jars of water in steam-air mix-

tures at near zero velocity (Fig. 3) agree with the data reported by Pflug and Nicholas (7) within limits of experimental error.

The differences in the heating rates at 165, 180 and 195° expressed as the ratio of the change in f_h per 15°F. heating medium temperature rise are tabulated (Table 1) as a function of the heating medium velocity. Three factors that may contribute to this increase in the rate of heating (decrease in f_h) with increasing temperature are: (1) an increase in the thermal diffusivity of the water and a decrease in viscosity at the higher heating medium temperature, affecting both water inside the jar and water film on the outside of the jar, (2) an increase in the convective flow inside the jar produced by the initially larger temperature difference between the heating medium and the product in the jar and (3) an increase in the convection heat transfer coefficient with increasing steam-air mixture temperature. The first two factors are not functions of the heating medium per se; therefore, the observed decrease in f_h with increased heating medium temperature can be only partially an effect of the steam-air heating medium.

TABLE 1—Comparison of f_h at maximum test velocities of steam-air mixtures with water spray

Temperature of heating medium	Water spray[7]	Steam-air mixtures	
°F.	f_h, min.	f_h, min.	Velocity ft. per sec.
165	10.0	10.6	5.5
180	9.7	9.7	6.0
195	9.5	8.6	8.0

It seems probable that the major effect is due to an increase in the convection heat transfer coefficient of steam-air mixtures with increasing temperature since the reduction in f_h with a 15°F. increase in heating medium temperature observed by Pflug and Nicholas (7) for water bath, water spray, and saturated steam heating averaged only 5 percent compared to a reduction in f_h from 8 to 22 percent, depending on velocity (Table 2), with the temperature of steam-air mixtures. It seems probable from these comparisons that from 50 to 75 percent of the decrease in f_h with increasing heating medium temperature is due to the steam-air heating medium.

TABLE 2—Ratio of the change in f_h per 15°F. heating medium temperature rise as a function of heating medium velocity

Velocity ft. per sec.	Ratio $\frac{1-f_{h\,180}}{f_{h\,165}}$	Ratio $\frac{1-f_{h\,195}}{f_{h\,180}}$
0.2	0.21	0.22
0.5	0.18	0.20
1.0	0.15	0.17
2	0.12	0.15
4	0.10	0.12
6	0.08	0.10

The transfer of heat from a steam-air mixture is a typical example of heat transfer from a mixture of a vapor and non-condensable gas (see Kern, 4). When a mixture of a vapor and a non-condensable gas comes in contact with a surface that is below the dew point, a film of condensate collects on this surface and a film of non-condensable gas and vapor develops adjacent to this condensate film. The rate of sensible heat flow from the fluid to the surface will be a function of the resistances of these films and the temperature difference driving force. At the same time the rate of heat transfer by vapor movement to the surface followed by condensation will depend on the resistance of these films to mass transfer or diffusion.

Kusak (5) has found that for steady-state condensation of vapors from a non-condensing gas that apparent film coefficient for a system may be satisfactorily correlated using the equation:

$$h_a = a\left[\frac{GD}{\mu LD}\right]^{\frac{1}{3}} e - cM_a$$

where

a, c = experimental constants
D = diameter of condenser, ft.
e = Napierian base 2.718 . . .
G = mass velocity of fluid, lb/hr.(ft.^{2} of cross section)
h_a = fictitious gas conductance including all conductances between bulk of gas and condenser surface at L feet from entrance Btu/(hr.)(ft.^{2})(°F.)
L = length of condenser, ft.

M_a = mole fraction air in the gas-vapor steam
μ = absolute viscosity, lb./(hr.)(ft.)

Since Kusak has shown that the gas film is the principal resistance, it is, therefore, not surprising that h is a function of flow rate G in the same manner as for non-condensing fluids. Steady-state forced convection heating of such fluids outside tubes may be satisfactorily correlated using the equation (6):

$$\frac{h_m D_o}{K} = b_1 \left[\frac{D_o G}{\mu}\right]^n \left[\frac{C_p \mu}{K}\right]^m$$

where

b_1 = experimental dimensionless constant
C_p = specific heat of film Btu/(lb. fluid)(°F.)
D_o = outside diameter, ft.
G = mass velocity of fluid, lb/(hr.)(sq. ft.^{2} of cross section)
h_m = mean surface coefficient of heat transfer Btu/(hr.)(ft.^{2})(°F.)
K = thermal conductivity of film, Btu/(hr.)(ft.)(°F.)
m, n = dimensionless experimental exponents
μ = absolute viscosity of film, lb/(hr.)(ft.)

In both equations, h, the convection heat transfer coefficient, varies directly with G^n; therefore, an increase in the velocity of heating medium past the container should produce an increase in the rate of heating. This phenomenon, in general, explains the relationship shown in Fig. 3; f_h decreases (rate of heating increases) with increased velocity. The effect of velocity on the decrease in f_h with increasing heating medium temperature can be partially explained by an analogy between heat and mass transfer presented by Kern (4) where he indicates that the quantity of vapor transferred in a system increases with the sensible convection heat transfer coefficient h, which is, in turn, a function of velocity.

The diffusivity of a condensing gas diffusing through a non-condensing gas was calculated by an equation (13.31) recommended by Kern (4) and the diffusivity in sq. ft. per hr. for 165, 180 and 195°F. was found to be 1.15, 1.20 and 1.26, respectively. The diffusivity increased 4.8 percent from 165 to 180° and 4.6 percent from 180 to 195°F. This change in diffusivity at least partially explains the decrease in f_h with increasing heating medium temperature. The saturation pressure also increases with temperature, hence increasing the

total diffusion potential. In addition, this phenomena may be interrelated with factor (2) above.

Insulating the retort caused the f_h of the jars to increase. Since at velocities other than zero insulating the retort cannot affect velocity, the effect must be due to some other factor. In the uninsulated retort, due to the increased load, there is considerably more steam flow into the retort for a given velocity than for the insulated retort. Since the velocity past the jar is the same, a considerable quantity of steam will have condensed in the bottom of the retort; some of this condensate may be present in the form of fog, altering the heat capacity and heat transfer characteristics of the steam-air mixture.

There is no known relationship between f_h and j for convection heating as there is for conduction heating products with finite film resistances (see Ball and Olson (1)). Pflug and Nicholas (7), in their study of the effect of heating medium, found evidence which suggests that f_h and j may be either interrelated or functions of a common parameter. There are subtle suggestions of the dependence of f_h and j by the data shown in Fig. 2.

Application of Data to Commercial Conditions

At the present time, there appears to be no way that these heating data can be used to predict the heating rate of food products in a steam-air mixture in commercial pasteurizing machines, since it is not possible to evaluate their temperature or velocity. The temperature of the steam-air mixture changes markedly from the inlet of the pasteurizer to the point most distant from the inlet. The temperature of the steam at the pipe orifice will be approximately 212°F. As the steam moves away from the nozzle it mixes with air so that by the time it reaches the bulb of the control device it is at the desired temperature which in commercial practice may be anywhere from 150° to 205°F.

General assumptions regarding the temperature pattern can be made, assuming the heating medium moves in a straight line from the steam orifice to the control point and on to some third point. If the container of food being heated is located between the sensing element of the control device and the steam nozzle, it can be assumed that the heating medium temperature to which the container is exposed will always be between the control point temperature and steam jet temperature.

If, on the other hand, the container of food is located between the sensing element of the control device and point 3, the temperature will always be below the control point temperature and will be somewhere between the control temperature and the temperature at point 3. This variable temperature heating pattern may be contrasted with saturated vapor heating where the temperature is for practical purposes constant throughout the system.

The velocity factors can be determined from a consideration of the typical pasteurizer unit. The commercial steam-air pasteurizer consists of a rectangular tunnel about 100 ft. long, 7 ft. wide and 2 ft. deep, open at both ends; there is a chain conveyor in the bottom and the steam distribution headers run lengthwise.

The units are usually made in sections 10 ft. long with canvas baffles between sections to keep drafts from blowing the steam-air mixture out of this open box. The velocity of the steam-air mixture past the container is a criterion of the steam jet design, the quantity of steam issuing from the jet, the degree of fullness of the pasteurizer and the location of the container in reference to the steam jet. The steam-air mixture velocity therefore is a function of heat load; a half full pasteurizer will have a lower velocity than a full pasteurizer and the velocity in a nearly empty pasteurizer will approach zero.

The results of this study indicate certain guiding principles for steam-air pasteurizer operation: (1) The heating medium temperature should be as high as proper product processing conditions will permit. (2) The steam distribution system should be designed to deliver steam uniformly to all points of the heating section at widely varying steam flow rates. (3) The location of the temperature control sensing element is very important since it is probably necessary to control temperatures over a range rather than at a point. (4) Although increasing the design velocity of the steam-air mixture may not be possible, the operators of steam-air pasteurizers, however, should be aware that the velocity is lower in a nearly empty pasteurizer than it is in a full pasteurizer.

SUMMARY

The effect of the velocity of steam-air mixtures on the f_h of jars of water has been determined at 165, 180 and 195°F. for velocities ranging up to 8 ft. per sec. The f_h decreases with increasing velocity and with increasing heating medium temperature. The j value remains approximately constant.

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EVALUATION OF CARPATHIAN WALNUT VARIETIES

By W. N. FISCHER[1], F. L. S. O'ROURKE[2], and R. R. DEDOLPH[2]

THE CARPATHIAN STRAIN of the Persian (English) walnut was introduced into Ontario, Canada from Northern Poland in 1934 by the Reverend Paul C. Crath.[3] In 1935, he supplied the Wisconsin Horticulture Society with a large quantity of seed nuts which were distributed to interested individuals in several midwestern states, including Michigan. Many Carpathian walnut trees now in bearing owe their origin to this source.

Carpathian walnuts like other fruit and nut trees, are quite variable when grown from seed. Consequently, many growers have selected one or more of their best trees and used scionwood from its branches to graft upon inferior trees or upon the native black walnut, *Juglans nigra*, which forms compatible graft unions with the Carpathian. These selections or "clones," as they may be termed after they have been propagated, have been given various names or numbers by their owners. Only a very few have been submitted for official listing in the "Register of New Fruit and Nut Varieties[4]."

Several nut contests during the 1950's, under the sponsorship of various state organizations, stimulated the selection of many "varieties." By 1960, there were so many named, numbered or otherwise designated clones among the various growers that it was seemingly impossible to rate one above the others. The senior author, at that time the chairman of the Research Committee of the Michigan Nut Growers Association, established a plan to evaluate the nuts of these various varieties each year for several years and, thus, to select only those with superior characteristics for further propagation and testing.

[1]Farm manager, W. K. Kellogg farm, MSU substation. Deceased, April 10, 1961.
[2]Assistant professor of horticulture, M.S.U.
[3]Devitt, L. K. (1953). The late Rev. Paul C. Crath. Northern Nut Growers Assn. Ann. Rpt. 44: 80-83.
[4]Brooks and Olmo (1944-1961, irregularly). Proc. Am. Soc. Hort. Sci. Vol. 45: 76.

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METHODS AND MATERIALS

In the early fall of 1960, growers were requested to send the senior author a random sample of 100 nuts from a single tree of a named or numbered clone. Thirty such samples were received and each divided into 20 lots of five nuts each, so that each of 20 selected judges would have a five-nut sample of each of the 30 varieties.

The judges were selected on the basis of their interest in agriculture and agricultural products. Few of them were nut culturists. Familiarity with favored varieties and personal bias were thus minimized. The samples were labeled and listed under coded numbers.

The judges rated the coded nut varieties in order of preference. The ratings used in this analysis were based on a scale of zero through 10. The zero rating indicated that the nut sample was unacceptable, and the 10 rating that it was superior with respect to size, flavor, and appearance. The differences between score means were delimited by methods proposed by Duncan[5].

RESULTS AND DISCUSSION

The judges selected eight varieties as being consistently better than any of the remaining 22 (Table 1). Average scores among the lower scoring varieties ranged up to 2.30. Though there were differences within this low scoring group, the variety scoring highest in this group was substantially lower than the lowest scoring variety among the top eight, so the group as a whole and the differences within this lower group will not receive detailed consideration.

The scores among the highest ranking varieties showed marked differences (Table 1). Somers N-2,W-4 can be classed with Hansen

[5]Duncan, D. B. (1955). Multiple range and multiple F tests. Biometrics 11: 1-42.

TABLE 1—Relationship between varieties of Carpathian walnuts based on market quality according to judges' scores of the highest ranking eight varieties in 1960

Variety	Average score	Variety	Average score
Hansen	6.35a	Somers NC-4	4.65bc
Somers N-2, W-4	5.35ab	Noggle	3.70cd
Van Buren	5.00b	Somers N-1, W-3	3.55d
Fickes	4.72bc	Somers N-1, W-4	3.50d

Varieties rated 0-10. 0 rating = unacceptable; 10 rating = superior. Mean scores not subtended by the same letter are different at odds of 19:1.

among the top scoring types. Van Buren, Fickes and Somers NC-4 may be classed with Somers N-2,W-4, but did not score sufficiently high to class with Hansen. Noggle may be classed with Fickes and Somers NC-4, but with none of those scoring higher than Fickes. Somers N-1,W-3 and Somers N-1,W-4 may be classed with Noggle.

CONCLUSIONS

This report indicates that eight superior nut varieties rank higher in market quality than others and probably furnish the best source of propagating material at this time.

SOME ATTITUDES AND APPROACHES OF HOMEMAKERS TO FOOD BUYING[1]

By MARY D. ZEHNER and JAMES D. SHAFFER

Department of Agricultural Economics

Homemakers' attitudes and approaches to food buying influence their responses to (1) consumer education messages (2) advertising messages of different types and media and (3) merchandising and pricing practices. A better understanding of these attitudes and approaches is, therefore, important for consumer education and marketing food.

This report is based upon an exploratory study of food buying behavior. The questions used in the survey were open-ended and relatively unstructured. They were designed to obtain a variety of responses which will be useful in formulating hypotheses for future research.

The report consists of a summary of responses to these open-ended questions about food buying given by 257 homemakers in Lansing, Michigan, during 1959.[2]

The following is a brief preview of some of the findings:

(1) The majority of families do not use a formal food budget.

(2) The majority of homemakers shop first and then make up menus from available food stocks rather than plan menus and shop for those foods required.

[1]This report is drawn from a master's thesis by Mary D. Zehner entitled, "An exploratory study of consumer food buying decisions, Lansing, Michigan, (1961)," department of agricultural economics, Mich. State Univ.

[2]This study may be considered complementary to O'Brien, Carol B., (1961), The management process used in food shopping, Mich. Agr. Expt. Sta. Tech. Bul. 282. The studies are complementary in that they deal in part with similar areas of information, but are based upon different types of samples and questions. The study reported in Tech. Bul. 282 is based upon a sample of homemakers who shopped at three supermarkets during "busier times of the week." This excludes families (1) that shop at other types of stores, (2) that usually have a member other than the homemaker shop alone, (3) that usually shop during the less busy times of the week. The sample for the current study included all of the above types of families since it was selected on the basis of a random sample of residential addresses, but was biased in favor of homemakers who were more likely to be home during interviewing hours.

Also, while some of the questions were similar they were different. The current study used, in general, less highly structured and less specific questions allowing a wider range of response. The previous study dealt more with a specific shopping trip and less with homemakers' beliefs and attitudes about their shopping behavior. As would be expected, differences in responses occurred.

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(3) The majority of homemakers view their food expenditures as being fairly constant over long periods of time.

(4) Most homemakers view food shopping as a very important activity.

(5) Most homemakers use a shopping list, but plan to make many purchase decisions in the store.

(6) There is some relationship between the attitudes and approaches to food buying and socioeconomic characteristics of the family. However, the correlations are not high, indicating these attitudes and approaches might serve as useful variables in explaining differences in food purchases.

THE SAMPLE

The sample was obtained by systematic selection from the residential address section of the Lansing City Directory.[3] In order to conserve resources, two alternative addresses were selected to be contacted if the family of the primary address could not be interviewed after one call-back. Data for the study were obtained by personal interview. The length of the interview varied from 20 to 90 minutes with an average of 1 hour.

The 14-page questionnaire was divided into six subject matter areas: specific expenses, the basic food expenditure decisions, planning, buying, food preparation and general questions. Open-ended questions were used in order to obtain a wide variety of responses.

A comparison was made with a sample census of 1,200 of the Lansing population to learn whether the characteristics of this sample corresponded with the larger reference sample. The comparison indicated an overrepresentation in the sample of the lower income households and households with children both under 10 and 10-19 years old. Fewer of the homemakers were employed outside the home in the study than in the larger reference sample.

The method of sampling with a primary, and two alternative addresses could be expected to result in this type of bias. Homemakers with one young child or just older children might more likely be away from home at the time of the interviewer calling than a homemaker with a larger family whose children's ages span more years.

[3]Published by R. L. Polk & Co. This section of the directory consists of addresses listed by street and number.

HOW MUCH TO SPEND FOR FOOD

Twenty percent of the average family's disposable income is used for the purchase of food.[4] The actual amount of money a family spends for food, however, is a function of environmental influences, past and present, which come to bear upon the individual homemaker in buying food.

The Initial Food Budget Decision

The homemakers were asked, "How did you originally decide on the actual amount of money you were to spend for food in a given period of time?" Their responses may be summarized as follows:

Trial and error method	26.1%
Buying what they want; cost not the limiting factor	25.7%
Budget by percentage of income	12.4%
Pay other bills first, use what is left for food	12.1%
Buy what is wanted, but not extravagant	7.0%
Felt never made original decision	7.8%
Pay food bill first, other bills later	5.8%
Other decision	3.1%

A majority of the homemakers reported they originally arrived at the amount of money spent for food through one of two procedures (1) trial and error, and (2) by buying what food they wanted without being extravagant, but also without fixed cost limits. The trial and error answer implies an experimental approach to determining the initial food budget — an attempt to find a satisfactory level of food expenditure by trial and error rather than starting with a rule, a fixed budget allocation or the fulfillment of an established preference pattern. The second response listed does not mean the homemaker could or would buy things without regard to cost, rather it should be taken to mean that they felt their incomes were adequate to provide for their established food preferences. In many cases, this was more a result of limited wants than unlimited incomes.

Eight percent of the homemakers felt they never had made a conscious initial decision about food expenditures. Nevertheless, it is obvious that the consumer must make some decisions in relation-

[4]Agricultural Marketing Service, *The Marketing and Transportation Situation*, Washington: U. S. Department of Agriculture, 1960.

ship to food expenditures, whether it is several small decisions or one more important choice that results in the amount of money to be spent for food.

The original decisions as to the amount of money to be spent for food were cross-tabulated with the characteristics of the family to determine what relationships existed.[5] Significantly, more heads of households in the low income level thought they had never made a conscious decision in respect to food expenditures. As would be expected, more homemakers among the higher income groups than among the low said they bought food without regard to cost.[6]

The General Approach to the Food Budget

Different value systems, the availability of resources, and the judgment of homemakers all influence the general approach to the food budgets.

When the homemakers were asked, "Which method would you consider your way of spending?," they responded as follows:

No specific limitations (long range planning)	23.3%
Formal budget	19.9%
Flexible spending guide	16.3%
Combination of several methods	16.0%
Household allowance	14.4%
No limits at all	9.7%
No answer given	0.4%

Significantly more homemakers with education beyond high school indicated the use of the flexible spending guide, and the long range planning approach. Homemakers with a high school education and homemakers with only older children at home said they relied on the household allowance approach to best fit their needs. The high income level and high educational level were significantly associated with homemakers placing no conscious limits on spending. Homemakers in the low income households more frequently said they utilized the formal budget.[7]

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[5]Chi-squares were used as the test for statistical significance. The term "significant" is used in the text only when the level of significance was at least at the 10 percent level.

[6]The income groups were under $4,000, $4,000-$7,000 and over $7,000. It should also be noted that families with incomes under $4,000 have fewer members on the average and thus many would rank higher if grouped by per capita income. The low income group also includes a much higher percentage of retired persons than the higher groups.

[7]It will be noted that significantly more homemakers of low income families, relative to higher income families, also reported they felt they never made an original decision concerning the amount to be spent for food. These may appear inconsistent unless it is recognized that the statements are relative to the other income groups. About 15 percent of the low income group reported "no decision" and about 30 percent reported the use of the formal budget.

Flexibility in the Basic Amount of Money Spent for Food

Most homemakers view the amount spent for food as being constant over fairly long periods of time. When asked, "How long have you spent the amount you are now spending for food?," 14 percent said less than 1 year; 17 percent, 1 year; 19 percent, 2 years; 25 percent, 3 to 5 years; 21 percent over 5 years; 2 percent, not constant and 2 percent gave no answer.

Certainly food expenditures for most families show significant week-to-week, month-to-month and year-to-year fluctuations. It should be noted that the 5-year period preceding this survey was a period of very stable food prices and fairly stable incomes in the survey area, thus reducing the need for adjusting food expenditures. The important point is, however, that the majority of homemakers viewed their food expenditures to be a fixed amount over long periods of time.

As would be expected, more older homemakers reported constant expenditures over longer periods than was true of younger homemakers. Similarly, the higher income group indicated more stable food expenditures than the lower groups.

Role of the Husband in Food Purchase Decisions

The majority of homemakers reported that their husbands played a role in family food buying decisions. Of the households with husbands present, 31 percent of the homemakers thought their husbands were very interested in food buying decisions; 31 percent thought they were mildly to fairly interested; and 36 percent of the homemakers believed their husbands had an attitude of complete indifference toward food purchases and the amount of money spent on food.

Of the characteristics of the family compared, the income level of the household showed the most significant relationship with the attitude toward food buying decisions. Husbands in the higher income group were reported as more indifferent toward food buying decisions, less likely to ask for an accounting for food expenditures, less frequently shopping for food, and less aware of food prices. Thus, there were more independent decisions made by the homemaker in the higher than lower income groups.

More homemakers in households where there were no children

at home reported that their husbands were aware of prices and expenditure and less likely to ask for an accounting.

FOOD MANAGEMENT AND SHOPPING BEHAVIOR

Planning and shopping constitute important segments of total food purchase behavior. Whether or not the initial decision as to how much money is to be spent for food is predetermined, the decision remains as to what planning and buying practices the homemaker will follow in spending the food dollar.

Use of a Shopping List

Three out of four homemakers reported making a shopping list before going to the store.[8] Forty-one percent of the homemakers reported making a complete shopping list, 36 percent said they made a partial list, 22 percent used no list, and 1 percent gave no response.

Homemakers with a high school education were significantly associated with making a complete list; those with education beyond high school, those aged 40-65, and those with no children under 20 at home most often indicated the use of the partial list; those homemakers who had not completed high school and those over the age of 65 tended to use no shopping list.

A high percentage (72 percent) of the homemakers reported they decided upon half or more of their food items before they reached the store. Three out of five homemakers planned on supplementing their list and making the final decisions in the stores.

Extent of Menu Planning

About 47 percent of the homemakers reported they typically "buy first and then plan meals around foods purchased;" 32 percent said they typically plan menus before shopping for food; 14 percent typically use a combination of these approaches while about 7 percent reported their shopping and meal preparation did not involve "planning." The great majority of homemakers seemed to plan few specific items for specific meals ahead but rather planned in a general way to have enough meat, vegetables, etc. to last from one shopping

[8] O'Brien, *op. cit.*, page 8, questioning shoppers in a supermarket, found 85 percent of the homemakers surveyed ". . . had figured out what they wanted to buy before entering the market," but only 50 percent reported they had a written list. The question in this study was more general, dealing with what the homemaker considered her usual practice not with a specific shopping trip. Neither did the question distinguish between a written and a mental list although a written list seemed implied.

trip to the next. Only for entertaining or special meals did many homemakers plan a specific menu before shopping.

Planning for Lunch and Dinner Expenditures Away from Home

About 40 percent of the families reported expenditures for lunches eaten out during the week preceding the survey. Of these, only 15 percent planned lunch expenditures as a part of the food budget, 46 percent assigned them as part of a personal allowance, 13 percent were on expense account, 4 percent made them a special budget category and 22 percent made no special arrangements for lunch expenditures.

Almost 40 percent also reported at least one member of the family eating dinner out during the previous week. Only 17 percent of those eating dinners out considered them as part of the regular food budget.

The Influence of Weight Problems in Food Buying

A recognized weight problem with the homemaker and or the husband had little effect upon the family's per capita expenditure for food. Although there was no statistically significant relationship, there were some indications that a greater proportion of homemakers with a recognized weight problem in the family tended to emphasize the importance of food by proportionately planning more specific menus before shopping, less compulsion to stay within a budget, and more concentration on food, rather than other distracting factors (the presence of children on the shopping trip and concentrating on plans for after shopping) as they shopped in the grocery store.

ATTITUDES TOWARD FOOD MANAGEMENT

Consumers' Goals as they Relate to Food

When asked what their goals were as they shopped for food, 29 percent of the homemakers stated their primary goal was to provide the family with satisfying, appealing meals, with variety; 37 percent listed well-balanced nourishing meals and the health of the family, and 31 percent indicated staying within a budget as their major goal.[9] To have enough food for the planned period was the goal given by 13 percent of the homemakers. Three percent stated no

[9]The specific question asked was, "What are your goals as you shop for food — what do you hope to accomplish?"

goals, while 12 percent of the sample of homemakers felt their primary goal was a matter-of-fact "to keep us (myself) fed."

Within increases in the level of income, homemakers' goals expressed more of the psychological aspects of food (satisfying, appealing meals to keep the family happy), and fewer were concerned about staying within budgetary limits.

Attitude Toward the Job of Shopping

The job of food shopping was very important to 87 percent of the homemakers who considered it an integral part of the total responsibility of the homemaker. Eleven percent of the homemakers stated the job of shopping was not important to them, and 2 percent considered it less important than planning involved before shopping.

Fifty-three percent of the homemakers preferred to do their own shopping rather than allow someone else to do it for them. This preference to do their own shopping was associated with the homemakers' expressed feelings that she was best equipped to shop to meet the needs of the family, shopping was an enjoyable experience, and better values could be obtained by making the final decision in the store. Of the 46 percent of the homemakers who would transfer the responsibility, the husband or someone else in the family was frequently mentioned as the only others who would be qualified for the job. One percent gave no response to the question.

Thoughts While Pushing the Grocery Cart through the Store

Responses given to the question, "What do you think about as you push the cart through the store?" indicated that homemakers' attention was not held completely by thoughts of foods and decisions related to food in the grocery store.

One-half of the homemakers mentioned concentrating on food itself, i.e., meal planning, looking for foods their family would enjoy, food quality, or the shopping list while in the store. Prices and budget limits were stated as the concern of 26 percent of the homemakers.

Forty-seven percent of the homemakers reported they concentrated on something other than food, such as what they were going to do after shopping. Children presented a distracting influence on their mothers as they "tried to keep the children from buying every-

thing advertised on television and keeping them off the shelves." Many homemakers with experience in shopping apparently felt they had such firmly established habits that they rarely thought of food while in the store.

Feelings Upon Completion of Grocery Shopping

Homemakers, upon return from the shopping trip, said they experienced mixed feelings. Almost one-half of the homemakers indicated satisfaction of "a job well-done," which perhaps was related to the homemakers' thinking of shopping as a pleasant experience and giving the satisfying feeling that the family had enough food for the week.

Twenty-five percent of the homemakers indicated the feeling of fatigue, worry and frustration upon completion of the shopping trip. Pressure of time, dislike of putting groceries away, worry about exceeding the planned amount of money for food, and not getting good values for the money spent, all contributed to these feelings.

Importance of Cooking and Eating

The importance of cooking and eating to the homemakers appeared to be related to the presence of a family at meals and the responsiveness of the family members to the foods being served. Meal time provided a pleasant experience for most of the homemakers, but irregular time schedules of the family and discipline problems with the children sometimes made meal time less enjoyable.

The homemakers' attitude toward cooking was shown by the feeling that through cooking, it was possible to bring happiness and pleasure to others. Cooking was significantly more important to, and more highly valued by homemakers with children at home. Some homemakers, however, felt they were not spending as much time cooking because the convenient foods and the advanced processing techniques had reduced the time essential for food preparation.

Consumers' Interest in Information on Food Buying and Planning

The homemakers offered the following suggestions to the question, "If you could have at your service a specialist in food planning and buying, what suggestions or information would you want?"

Help with meal planning (stated in terms of ideas with menus and recipes) 22.6%

Economy — how to manage food money more economically	16.7%
Food buying and selection	13.6%
Preparation methods	11.7%
Nutrition	9.7%
Preservation, storage, spoilage	8.9%
Time management	3.9%
Other	6.6%
No suggestions	33.5%

Food interests and problems of homemakers centered around the constant job of keeping their menus varied and of meeting the food preferences of the individual family members, while keeping food costs at a reasonable level.

One-third of all homemakers questioned had no suggestions about needed food buying and preparation information. Included in this group were both those who had no particular interest regarding food and others who felt they had a great deal of experience and who considered themselves to have no problems with planning and buying food.

THE EFFECT OF GIBBERELLIC ACID ON DEVELOPMENT OF THE CHICKEN EMBRYO

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INTRODUCTION

Marked interest has been shown by numerous investigators in the biological properties and the effects of the gibberellins on plants. These researchers have hoped that coupled with the quest for new knowledge concerning the basic mechanism for growth regulation and development in plants, agricultural utilitarian purposes could be demonstrated. The wealth of experimental literature presently available on the effects of the gibberellins on field and green house plants attests to the widespread scientific attention and interest which they have excited. No attempt is made herein to review the voluminous literature on the effects of the gibberellins on plants. Excellent reviews, bibliographies and evaluations on the gibberellins have been published, (2, 3, 9, 10, 13).

In contrast to the veritable explosion of knowledge on the reactions of plants to gibberellins, there is a notable dearth of parallel information on the effect of gibberellins on animals except as it pertains to toxicological studies. These animal data could, in some cases, bear close association to the plant data by reason of residue considerations. However, analytical methods presently available, which are sensitive to less than 1 ug ml., are unable to detect gibberellin residues in harvested plants (8).

In the 1957 toxicological studies of Peck and co-workers, no adverse reactions were observed when gibberellic acid-containing preparations were administered intravenously and orally to mice and rats, fed in the diet or sprayed on rats, or applied to the eye of rabbits. Further, these researchers inoculated gibberellin into cultures

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of Rhesus testicular cells, Hela cells and stable human amnion cells. Toxic reactions or cell growth stimulation were not observed. From the results of these tests, it was concluded that gibberellic acid or its salts, when used according to the directions, offers no hazard to those who use it for agricultural purposes nor to those who consume products on which it has been used.

According to Merritt (7), sheep grazed on gibberellin-treated pastures in New Zealand suffered no ill effects. Broiler chicks fed starter rations containing gibberellin at the levels of 0.2, 2.0 and 20 grams per ton of basal ration showed no significant differences in growth rate, feed efficiency and livability (12).

Included in the spectrum of effects of the gibberellins on plants is that of promoting or stimulating cell enlargement and cell division. To our knowledge, investigations on the effect of gibberellin on the proliferation of animal tissues and cells in *vivo* have not been conducted. Stodola (9) cites that *in vitro* studies using embryonal chicken heart tissue cultures injected with crystalline gibberellin have been conducted by workers at the Japanese Foundation for Cancer Research (4, 6, 14). In these particular experimentations, no evidence of any action was observed.

The purpose of this paper is to present some preliminary data concerning the effects of injecting the potassium salt of gibberellin GA_3 (GIBREL[2]) into incubating chicken eggs.

EXPERIMENTAL PROCEDURE

Pedigreed hatching eggs were obtained from the females of two strains (herein designated as Strain A and Strain B) of S. C. White Leghorns. One day prior to injection the eggs were weighed to the nearest ½ gram. Each egg was prepared for injection by washing a portion of the shell surface at the large end of the egg with a solution of alcohol containing 0.5 percent of iodine. A small hole was punctured in that part of the shell above the air cell using a 2-inch, 20-gauge sterilized hypodermic needle. Between each puncture operation the needle was flamed over an alcohol lamp.

Sterilized Ringer's solution was used as the diluent for the potassium salt of gibberellin (GIBREL). A 0.3 ml. volume of the gibberellin-containing solution was injected into the albumen of each treated egg with a sterilized 26-gauge hypodermic needle and a 1 cc. tuberculin

[2]The potassium gibberellate (GIBREL) for this experimentation was supplied by courtesy of Merck and Co., Inc., Rahway, New Jersey.

syringe. Following the injection, each hole punctured into the shell of an egg was sealed with hot melted paraffin wax. The eggs which served as the controls were of two classifications: (a) those eggs injected with 0.3 ml. of the diluent and (b) those eggs in which simply a hole had been punctured and which were immediately sealed with paraffin wax.

Fresh solutions containing the desired concentration of the potassium salt of gibberellin (GA_3) were made up one day prior to use in each test. After injection and sealing, the eggs were set in a single stage forced draft incubator which was operated according to the directions of the manufacturer. Periodically after injection, the eggs were removed from the incubator and candled. Those eggs which appeared under the candle to be infertile or which contained apparent dead embryos were removed and broken-out for macroscopic examination. Criteria for classifying the approximate age of embryos at time of death were based upon the series of stages and the external morphological characters outlined by Hamilton (5). Eggs containing live embryos were returned for further incubation. On the 18th day of incubation, the eggs were again candled, and eggs containing live embryos were transferred from the setting incubator unit to an incubator which was operated as a hatcher unit. Again, eggs removed on the date of transfer were broken-out for macroscopic observation. All eggs remained in the hatcher for 24 days to determine the effect, if any, of treatment on time required to hatch. However, when any hatched chicks were fluffed-out, they were removed from the incubator and weighed to the nearest gram. In Test 1, the chicks which hatched were brooded to 2 weeks of age in a wire-bottom battery brooder at which time body weights were taken. The hatchability data for the eggs injected with various dosage levels of gibberellin prior to incubation in Tests 1, 2 and 3 and pertinent embryo classification data are presented in Table 1.

The number of eggs which were transferred from the setter to the hatcher on the 18th day of incubation, the number of chicks hatched, the number of days required to hatch, the day-old chick weight and two week body weight are presented in Table 2. Tables 3, 4 and 5 present the results of injecting eggs which had been embryonating for 3½, 4½ and 8 days, respectively. The results obtained with the two types of control eggs are shown in Table 6.

TABLE 1—Hatchability and embryonic mortality data for eggs injected with gibberelin prior to incubation

Dosage level, mg. gibberellin	Test No.	No. eggs set	No. I	No. R	No. alive at 18 days	No. chicks hatched	Approximate time of embryonic death											
							Hours				Days							
							24	24–48	48–72	72–96	5 and 6	7 and 8	9 and 10	11 and 12	13 and 14	15 and 16	17 and 18	19 and 20
0.1	I	20[1]	5		3	3	1											
	II	22	2		9	3	1	3	2	5						2	1	
	III	21[2]	4		4	1	6	6									2	4
																		1
1.0	I	20[3]	4		5	3	3	2		1							3(*a*)	
	II	22	6		7	3		5	2		1						3	2 (*b*)
	III	21[4]	4		5	1	4			1	1	2		1		1	2	2(*c*)
10.0	I	20[5]	7		4	1	3					1			2		2	1
	II	22	2	5	8	3		2	1		1			1	1	1	4	2
	III	21[6]	6		7	5	4				1							2
100.0	I	20	6	5	0	0	1			2					1	2	3	
	III	21[7]	2	2	5	2	4			1			1			1	4	1
150.0	II	22	6	7	0	0	2	1		1			3	1			1	
	III	21	1	6	3	0	4					3	2	1		1	2	1

(*a*) Visceral ectopia in 1 embryo.
(*b*) Severe blood vessel network (B.V.N.) hemorrhage in 1 embryo.
(*c*) Hemorrhages of yolk sac in 2 embryos.

I = Infertile. R = Rots.

1 8 alives broken-out, normal.
2 1 alive broken-out, normal.
3 4 alives broken-out, normal.
4 2 alives broken-out, normal.
5 2 alives broken-out, normal.
6 3 eggs broken.
7 3 alives broken-out, normal.

TABLE 2—The hatchability, time required to hatch, day-old and 2-week old weight of chicks hatched from eggs injected prior to incubation with gibberellin

Dosage level, mg. gibberellin	Test number	No. eggs set	No. alive at: 18 days	No. chicks hatched	No. days required to hatch	Body wt., gms. at hatching	Body wt., gms. at 2 weeks
0.1	I	20	3	3	21-21-21	37-39-39	103-107-113
	II	22	9	3	21-23-21	37-35-38	
	III	21	4	1	21	41	
1.0	I	20	5	3	21-21-23	36-39-37	99-98-104
	II	22	7	3	21-21-22	33-35-38	
	III	21	5	1	21	40	
10.0	I	20	4	1	21	39	99
	II	22	8	3	21-22-22	38-35-37	
	III	21	7	5	21-21-21-21-22	35-38-41-39-41	
100.0	I	20	0	0			
	III	21	5	2	22-23	36-37	
150.0	II	22	0	0			
	III	21	3	0			

RESULTS AND DISCUSSION

Injections Prior to Incubation

The evidence presented in Table 1 demonstrates that gibberellin (GA_3) injected at the levels of 0.1, 1.0 and 10.0 mg. into the albumen of eggs laid by the domestic fowl did not inhibit embryonic development. In each of three tests (Test I, II and III), chicks were hatched from eggs irrespective of the quantity of gibberellin injected prior to incubation. Only in Test III were chicks hatched following the injection of 100.0 mg. of gibberellin per egg. Of the 43 eggs injected prior to incubation with 150 mg. of gibberellin, only three embryos were alive at 18 days of incubation and these embryos failed to hatch.

The data presented in Table 2 shows that gibberellin injected at the 0.1, 1.0 and 10.0 mg. levels did not result in a prolongation of the time required to hatch an egg of the chicken incubated under optimum conditions of incubation. At the 100 mg. level, the two chicks which hatched in Test III required 22 and 23 days to hatch. However, this departure from the "normal" 21-day hatching period cannot be considered to be a significant deviation (1).

The day-old body weights of specific chicks hatched from specific eggs injected with 0.1, 1.0, 10.0 and 100 mg. of gibberellin prior to incubation were within the expected day-old body weight recovery

TABLE 3—The results of injecting gibberellin into embryonating chicken eggs after 3½ days of incubation, (Test IV)

Dosage level, mg. gibberellin	No. eggs set	No. I	No. R	No. alive at: 7 days	No. alive at: 18 days	No. chicks hatched	No. days required to hatch	Day-old chick wt. gms.	Approximate time of embryonic death, days 4—5	6—7	8—9	10—11	12—13	14—15	16—17	18—19	20	Remarks
0.1	14	1	0	3	2	2	21, 21	35, 40	5	5			1					
1.0	14	0	1	2	1	0	—	—	5	6	1						1	B.V.N. hemorrhage (1)
10.0	14	0	1	6	2	1	22	32	5	3			1	1	1	1		
100.0	14	2	6	4	2	2	21, 22	40, 41	2						2			
150.0	14	0	9	5	1	0	—	—			1			1	2	1		

I = Infertile. R = Rots. B.V.N. = Blood vessel network. ( ) Number of embryos observed.

TABLE 4—The results of injecting gibberellin into embryonating chicken eggs after 4½ days of incubation, (Test V)

Dosage level, mg. gibberellin	No. eggs set	No. I	No. R	No. alive at: 7 days	No. alive at: 18 days	No. chicks hatched	No. days required to hatch	Day-old chick wt. gms.	Approximate time of embryonic death, days: 5	6—7	8—9	10—11	12—13	14—15	16—17	18—19	20	Remarks
0.1	14	0	3	0	0	0			11									B.V.N. hemorrhages (2)
1.0	14	0	3	1	0	0			10					1				B.V.N. hemorrhages (3)
10.0	14	0	0	0	0	0			14									
100.0	14	0	6	1	0	0			6	1	1							Severe B.V.N. hem. (1)
150.0	14	0	7	3	1	1	21	40	4		1				1			B.V.N. hemorrhages (3)

I = Infertile. R = Rots. B.V.N. = Blood vessel network. ( ) Number of embryos observed.

TABLE 5—The results of injecting gibberellin into chicken eggs which had been embryonating for 8 days. (Test IV and V)

Dosage level, mg. gibberellin	Test No.	No. eggs set	No. I	No. R	No. alive at: 11 days	No. alive at: 18 days	No. chicks hatched	No. days required to hatch	Day-old chick wt., gms.	Approximate time of embryonic death, days: 9	10—11	12—13	14—15	16—17	18—19	20	Remarks
0.1	IV	14	0	1	3	0	0	—	—	9	1	1		2			
	V	12	0	7	3	1	0	—	—	2		2				1	
1.0	IV	14	0	4	1	0	0	—	—	6	3			1			
	V	12	0	2	2	2	0	—	—	8					1	1	
10.0	IV	14	0	5	2	1	1	21	40	5	2	1					
	V	12	0	4	3	2	1	22	—	5					2		Severe B.V.N. hem. (1) Pipped (1)
100.0	IV	14	0	12	0	0	0	—	—	2							
	V	12	0	6	2	0	0	—	—	4		1	1				Cerebral hernia (1) B.V.N. hemorrhage (4)
150.0	IV	14	0	11	3	3	1	21	36						1	1	
	V	12	0	4	5	0	0	—	—	3		1	2	1	1		Severe B.V.N. hem. (3)

I = Infertile. R = Rots. B.V.N. = Blood vessel network. ( ) Number of embryos observed.

TABLE 6—Control data

CONTROLS

Controls	Test No.	Time of injection	No. eggs set	No. I	No. R	No. alive at: 7 days	No. alive at: 18 days	No. chicks hatched	No. days required to hatch	Body wt., gms. at hatching, range	Body wt., gms. at 2 weeks, range
a) Ringer's solution	I	Prior	20	1	0		17	10	All 21	36 to 39	111 to 120
	II	to	22	5	0		10	9	7@21, 2@22	37 to 40	
	III	incub.	20	3	0		13	10	All 21	38 to 40	
b) Hole punched	I	Prior	20	3	0		17	9	8@21, 1@22	35 to 41	107 to 125
	II	to	22	4	0		12	8	6@21, 2@22	39 to 41	
	III	incub.	20	1	0		17	16	13@21, 3@22	35 to 40	
a) Ringer's solution	IV	3½ days	14	1	1	5(*a*)		4	All 21	33 to 39	
	V	4 days	12	1	0		8	6	5@21, 1@22	—	
	IV	8 days	14	0	0		8(*a*)	6	3@21, 3@22	36 to 40	
	V	8 days	12	0	0		7	5	3@21, 2@22	—	
b) Hole punched	IV	3½ days	14	0	0	12		10	9@21, 1@22	30 to 41	
	V	4 days	10	1	0	9		6	All 21	—	
	IV	8 days	10	0	0		8	7	5@21, 2@22	35 to 38	
	V	8 days	7	0	0		4	4	All 21	—	

I = Infertile. R = Rots. (*a*) 1 alive broken-out, normal.

range for eggs, the original egg size of which ranged from 52.0 to 62.5 grams and which were incubated under optimum conditions of incubation. Similarly, no significant alteration in growth rate pattern to two weeks of age was observed. Therefore, under the conditions of the experiments herein reported, the potassium salt of gibberellin (GA_3): 1) did not stimulate abnormal cell division in the chicken embryo, 2) did not act as a nutrient to the developing chick embryo nor to the growing chick to 2 weeks of age, and 3) apparently did not act like, supplement nor alter the natural growth-promoting hormones and/or substances of the chicken embryo or of the growing chick to 2 weeks of age. While it cannot be stated with any degree of certainty that those embryos which succumbed during the incubation process did not undergo abnormal cell division, the live chick evidence supports the hypothesis that abnormal cell division did not occur.

During the course of the incubation periods in all tests, candled infertiles, dead germs and a portion of the eggs containing live embryos were broken-out for macroscopic examination. Although one embryo exhibited visceral ectopia, one embryo showed cerebral hernia and three embryos displayed body hemorrhages, these gross anomalies certainly could not be attributed to treatment *per se.*, as duplication of anomality could not be demonstrated. Therefore, injections of gibberellin did not result in gross deformities in embryonic tissue.

Further, in these experiments (Tests I, II and III) wherein injections of gibberellin were made prior to incubating the chicken eggs, no stereotype of embryonic mortality was apparent.

Injections at 3½ Days of Incubation

Injections of gibberellin at dosage levels of 0.1, 1.0 and 10.0 mg. per egg into chicken eggs which had been embryonating for 3½ days resulted in the death of the majority of the embryos within approximately 72 hours after injection (Table 3). However, some chicks were hatched from eggs which had been injected with 0.1, 10.0 and 100.0 mg. of gibberellin. No chicks were hatched from eggs injected with 150 mg. of gibberellin. There was no observable effect on time required to hatch nor on day-old chick weight. Over one-half (15) of the 28 fertile eggs injected with 100 and 150 mg. of gibberellin were candled and confirmed macroscopically as rots 3½ days post-injection.

Injections at 4½ Days of Incubation

Gibberellin injected into chicken eggs which had been embryonating for 4½ days resulted in embryonic death within about 48 hours post-injection (Table 4). Grossly, the 5 to 5-plus day-old embryos which succumbed exhibited moderate to severe hemorrhages in the blood vessel network surrounding the embryo proper. The physiological mechanism x gibberellin interaction involved in the hemorrhages noted is not clear. For reasons that are not immediately apparent, except for differential embryonic susceptibility or resistance, one chick hatched from an egg which had received 150 mg. of gibberellin, whereas chicks were not obtained from eggs injected with lesser dosages of gibberellin. The data pertaining to the number of rots observed after injection with 100 and 150 mg. of gibberellin after 4½ days of incubation is in agreement with those data from injections after 3½ days of incubation.

Injections at 8 Days of Incubation

As shown in Table 5, a total of three chicks were hatched from eggs which were injected with gibberellin after undergoing 8 days of incubation; two chicks which were from eggs which had been injected with 10.0 mg. of gibberellin and one chick from an egg which had received 150 mg. of gibberellin. At all dosage levels, most of the embryonic deaths occurred within 24 hours post-injection. However,

no observable effect of the injection was noted on speed of hatching nor on day-old chick weight. At the 10.0, 100.0 and 150.0 mg. levels of gibberellin, moderate to severe hemorrhages of the blood vessel network surrounding the body of the embryos were noted. Again, a high proportion of the eggs containing live embryos and which were injected with 100 and 150 mg. of gibberellin developed into rots.

General

The macroscopic data on the approximate age of the embryos at time of death post-injection were as follows: a) those embryos developing in eggs into which gibberellin was injected into the albumen after 3½ days of incubation died within about 72 hours after injection, b) those injected after 4½ days of incubation died within approximately 48 hours post-injection, and c) those injected after 8 days of incubation died within about 24 hours following injection.

Contrary to expectations, these results are suggestive that the chicken embryo is comparatively more sensitive to injections of gibberellin at that time in the developmental process when the tissues, organs and systems have undergone differentiation and specialization. If sensitization were to occur it would appear more likely to these researchers that the embryo would be more sensitive to injections of gibberellin at the time when all of the primordia for the various tissues and systems are in the initial stages of development, i.e., when they are in a primitive stage in the developmental process. In the investigation reported herewith, the reverse of this rationalization was observed.

Two observations made during the conduct of this investigation appear to be worthy of notation. First, at the 150 mg. level the gibberellin-containing solution was exceedingly viscous and difficult to inject. Secondly, a large proportion of the eggs injected prior to incubation and at various times during the incubation period with 100 and 150 mg. of gibberellin were removed as rots (Tables 1, 3, 4 and 5). Although the reason for the large proportion of rots is not clear, possible explanations are as follows: a) bacterial contamination, b) a marked alteration in the pH of the albumen of the egg which could cause protein precipitation or albumen coagulation with subsequent deterioration and c) embryonic death and subsequent deterioration. The absence of or small proportion of rots at the lower dosage levels in tests conducted concurrently with the 100 and 150 mg. levels,

coupled with the results obtained in the controls, would tend to minimize the acceptance of the bacterial contamination explanation. With respect to protein precipitation or albumen coagulation, it would appear highly unlikely that the small quantity of the potassium salt of gibberellin with a pH of about 5.8, and which was dissolved in Ringer's solution, would markedly alter the pH of the albumen (approximately 7.6) of a newly-laid chicken egg. Therefore, embryo decomposition is suggested as being primarily responsible for the large proportion of rots observed. Support for this hypothesis is derived from the data on time of embryonic death for those eggs injected after embryonic development had been initiated. In these tests (IV and V), for the majority of those embryos which succumbed, time of death was placed at 24 to 72 hours post-injection.

Strain differences in reaction to various dosage levels and time of injection of gibberellin were not observed.

SUMMARY AND CONCLUSIONS

Pedigreed hatching eggs from two pure strains of S. C. White Leghorns were injected with dosage levels of 0.1, 1.0, 10.0, 100.0 and 150.0 mg. of the potassium salt of gibberellin GA_3 (GIBREL) prior to incubation and into eggs which had been embryonating for 3½, 4½ and 8 days. Data were collected on the following: hatchability, approximate time of embryonic death, time required to hatch, day-old and 2-week body weight and gross anomalies.

Injections of gibberellin into the albumen of eggs prior to incubation did not inhibit embryonic development at the dosage levels of 0.1, 1.0, 10.0 and 100.0 mg. In Tests II and III, eggs injected with 150 mg. of gibberellin prior to incubation failed to hatch. A considerable number of the eggs injected with 100.0 and 150.0 mg. of gibberellin were removed from the incubator as rots. No prolongation of time required to hatch was observed. Day-old and 2-week chick weight did not markedly differ from the weights of control chicks.

With the reservations outlined, we interpret the live chick data as being suggestive that gibberellin: 1) does not stimulate abnormal cell division, 2) does not play an important role as a nutrient for the developing chick embryo nor to the growing chick to 2 weeks of age and 3) apparently does not act like, supplement or alter the natural growth-promoting hormones and/or substances of the chicken embryo or of the growing chick to 2 weeks of age. Further, gross anomalities

exhibited by embryos could not be attributed to treatment, *per se*. In addition, no stereotype of embryonic mortality was evident.

The majority of the embryos developing in eggs which were injected at 3½ days of incubation died within approximately 72 hours. However, chicks hatched from eggs injected with 0.1, 10.0 and 100.0 mg. of gibberellin. No effect on time required to hatch or on day-old body weight was observed. Over one-half of the fertile eggs which were injected with 100.0 and 150.0 mg. of gibberellin developed into rots.

Injections of gibberellin ino the albumen of eggs containing 4½ day old embryos resulted in embryonic death within about 48 hours. Grossly, moderate to severe hemorrhages in the blood vessel network surrounding the embryo proper, were observed. One chick hatched from an egg which was injected with 150 mg. of gibberellin. Again, a large number of rots were observed at the higher levels of injections of gibberellin.

Injections of gibberellin into eggs containing embryos which were 8 days of age resulted in a high proportion of embryonic deaths occurring within 24 hours. Of the three chicks which hatched from eggs injected with 10.0 and 150.0 mg. of gibberellin, speed of hatching and day-old body weight were not affected. Hemorrhages in the blood vessel network surrounding the developing embryo were again observed as well as a high proportion of rots at the two highest dosage levels of gibberellin.

It appears that the chicken embryo is more sensitive to injections of gibberellin after the various tissues, organs and systems have undergone differentiation and specialization rather than when the embryo is in primordial stages of development.

Embryonic death and subsequent deterioration was, in all probability, primarily responsible for the large number of rots observed after injections with 100.0 and 150.0 mg. of gibberellin.

Strain differences in reaction to injections of gibberellin both prior to and during various stages of the developmental process were not observed.

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GROWTH CHARACTERISTICS OF ASPARAGUS IN RELATION TO YIELDS FROM MECHANICAL HARVESTING

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Increased emphasis on labor efficiency has prompted much research on mechanized harvesting. The cost of harvesting asparagus by hand varies from a fifth to a third the value of the crop delivered to the receiving station. Kepner[1], reporting comparisons of hand with set-level machine cutting of asparagus in California, found that machine yields were 55 percent of hand harvested yields. He concluded that if machine yields could be increased to 65 percent of hand harvested yields, mechanical harvesting would be economically feasible. Reduced yields with mechanical cutting were attributed chiefly to the greatly increased proportion of short spears in the harvested product.

PROCEDURE

Yields from Mechanical Harvesting

In 1959, in an initial experiment, a tractor mounted cutter bar mower was compared with hand snapping[2] over a 15-day harvest period. Four single rows, each 100 feet in length, were hand snapped and four rows were mowed in a completely randomized design. The distal end of the cutter bar was supported by a rubber-tired wheel mounted to ride the undulations in the field and ensure a constant above ground cutting level.

In 1960, harvesting with a newly developed set-level machine[3] (Fig.

[1]Kepner, Robert A. (1957). Improved asparagus harvester. Calif. Agriculture 11(2):4-13.

[2]In this method, originated by Barrons (Barrons, Keith C. The field snapping method of harvesting asparagus. Mich. Agr. Exp. Sta. Quart. Bul. 28(2): 1-4. 1945) and employed almost exclusively in Michigan, the spear is grasped at the tip between the thumb and forefingers and bent over until it breaks. Breakage occurs ideally where fibers are beginning to form, giving a product of low fiber content, high quality, and little waste.

[3]The cooperation of the Friday Tractor Company of Hartford, Michigan in providing the machine for this work is hereby gratefully acknowledged.

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1) was compared to hand snapping in a completely randomized experiment involving 16 single row plots 100 feet in length, eight of which were harvested by hand snapping, and eight with the machine.

Fig. 1. The set-level asparagus harvester manufactured by the Friday Tractor Company of Hartford, Michigan. Photo on the left shows ground drive with V-belt pulley power transfer, leading edge with cutting blades and hitch frame. Photo on the right shows field lugs in carrier to catch harvested spears as they roll off the sloping cutter blades.

This machine is in essence an oversize reel-type mower having more than the usual number of cutting blades, made of wood for easy replacement. Spears are sheared between the wood blades and the leading edge of the steel partial cylinder in which the axle of the reel is mounted. Sheared spears are carried backward and upward by the wood blades, which fit the curvature of the cylindrical wall close enough to prevent crushing, and fall over the trailing edge of the partial cylinder into hoppers. The entire harvester unit is mounted on rubber-tired wheels which drive the revolving cutter. The unit is equipped with a tongue and drawbar hitch. Pulled by an International Cub tractor, the height of cut was immediately adjustable using the hydraulic lift.

Since the machine was not available until May 20, simulated machine harvesting was employed from the beginning of harvest, May 6, through May 20. During this period, in the plots designated for machine harvest, all spears were cut, regardless of length, at a uniform height of 2½ inches above the surface of the leveled soil. From May 20 through May 30, these plots were harvested with the machine set to cut all spears at a 2½-inch height.

In 1959, all spears from each plot were sorted into four spear-length classes: butts, spears less than 5 inches, spears 5-7½ inches, and spears more than 7½ inches in length. In 1960, spears from one of the hand and from one of the machine harvested plots were sorted into three spear-length classes. Numbers and weights were recorded.

Growth of new spears following harvesting was not as rapid in the machine as in the hand harvested plots either year. Following the suggestion of the manufacturer of the machine used in 1960, 10 percent of the spears in the machine harvested plots were allowed to become oversize before each harvest in an attempt to compensate for the number of short spears which previous experience had shown would be obtained.

Analysis of variance, covariance, and the Chi Square test for independence were the statistical procedures employed in reduction of the data.

Growth Characteristics of Asparagus Spears

It was anticipated that yield reduction would be commensurate with the number of undersize spears harvested and the number of unharvested spears injured sufficiently to prevent further development. A number of spears, 2, 4 and 6 inches above the soil surface, were marked at 2.5 cm. intervals along their length with India ink. In each length of spear group some spears were left to grow normally, a second group had the tip 1.25 cm. removed, and a third group had the tip 2.5 cm. removed, providing nine treatment combinations. Spears were selected at random in the field for these treatments. Twenty-four, 36 and 48 hours later, the measured distance between these marks, as well as total height, were recorded for each spear.

RESULTS AND DISCUSSION

Yields from Machine Harvesting

1959:

As a result of slower growth of new spears in the set-level harvested plots, only five harvests were obtained by mowing compared to seven by snapping in the 16-day trial harvest period, May 11-26.

On a weight basis, only 50 percent as much asparagus was obtained by mowing as by snapping (Table 1). Considering only those spears with intact tips, the yields obtained by mowing were only 40 percent of those obtained by snapping. From the mowed plots, 45 percent of

TABLE 1—Yields of asparagus harvested by mowing and by snapping (Sodus, 1959)

Length of spear	Mowed (5 harvests) (*a*)		Snapped (7 harvests) (*a*)	
	Lbs. per acre	Percent	Lbs. per acre	Percent
Pieces without tips	180	21.1	...	....
Less than 5 inches	215	25.2	248	14.6
5-7½ inches	245	28.7	1,048	61.8
More than 7½ inches	213	25.0	400	23.6
Total	853**		1,696**	
	Number(*b*)	Percent	Number(*b*)	Percent
Less than 5 inches	244	47.9	186	16.4
5-7½ inches	167	32.8	749	66.0
More than 7½ inches	98	19.2	199	17.5
Total	509**		1,134**	

** Totals significantly different at the 1% level of probability.
(*a*) In the period May 11-26, average of four replications.
(*b*) Average number of spears in each 100-foot row.

the yield was from spears less than 5 inches in length compared to less than 15 percent of such spears from hand harvesting. These results are in agreement with those reported by Kepner for machine cutting in California.[4]

In terms of number of spears with intact tips, there were significantly fewer that were 5 inches or more in length, and significantly more spears that were less than 5 inches in length from the mowed than from the snapped plots, as shown in Table 1.

The reduced total weight of spears obtained by harvesting, the relative concentration of the weight in short spears, and reduced weight in the desirable 5-7½ inch group, combined to substantially reduce the value of the crop obtained by machine harvesting.

1960:

Owing again to slower regrowth after harvesting in the machine harvested plots, only six pickings were obtained compared to nine from the snapped plots in the 24-day harvest period, May 6-30. As in the previous year, about 10 percent of spears were allowed to become oversize before harvesting the mechanically harvested plots.

[4]op. cit., footnote 1.

Yields from hand snapping were about 68 percent higher than those obtained by mechanical harvesting (Table 2). Size of spear was also influenced by method of harvesting. As shown in Table 2, there were almost as many spears less than 2 inches in length as there were spears greater than 5 inches in length from the machine harvested plot in which spears were sorted for size. Ninety-five percent of all spears harvested from the snapped plot in which spears were sorted by size were more than 5 inches long.

TABLE 2—Yield and size of spear in relation to method of harvesting asparagus (Sodus, 1960)

Size of spear	Values per single 100 ft. row					
	Machine harvested (6 harvests)(*a*)			Hand snapped (9 harvests)		
	No.(*b*)	Lbs./acre	Ozs./spr.	No.(*b*)	Lbs./acre	Ozs./spr.
<2 inches long ..	190	101	.115	0	0	....
2-5 inches long ..	149	198	.288	28	60	.455
>5 inches long ..	194	506	.568	485	1,310	.588
Totals.....	533	805**	.342	513	1,370**	.581

(*a*) In the period May 6-30, 1960. Simulated machine harvest in the period May 6-20, in the machine harvested plots.

(*b*) Number of spears in 100 ft. of row. $X^2 = 397$, $P > .01$ that the number of spears in the various size-of-spear categories are independent of method of harvesting.

** Totals significantly different at the 1% level of probability.

Essentially the same results were obtained by Kepner[5], using a below ground cutter in California, as in this Michigan experiment using two entirely different machines to cut spears off above the soil surface. All three machines failed to harvest yields comparable to those obtained by hand, primarily because harvesting was not selective for length of spear and, therefore, too many spears were harvested prematurely. This conclusion is further supported by the data shown in Table 3.

Other reports have neglected the important limitation imposed on potential yield by injury to the tips of young spears, the investigators perhaps assuming that such spears would be replaced by other buds[6]. Many of the small pieces of spears, those less than 2 inches and 2-5 inches in length, obtained by set-level harvesting were without tips

[5]Op. cit., footnote 1.

[6]See Kepner, footnote 1 and Tiedjens, V. A. (1926). Some observations on root and crown bud formation in *Asparagus officinalis*. Proc. Amer. Soc. Sci. 23:189-195.

TABLE 3—Number of spears in three size classes in relation to method and time of harvesting asparagus (1960)

Harvest period	Dates	Set-level harvested(a)				Hand snapped(a)			
		<2"	2-5"	>5"	Sum	<2"	2-5"	>5"	Sum
I	May 6	27	33	24	84	0	5	61	66
Simulated	10	..	..	..	..	0	2	27	29
Machine	16	46	21	40	107	0	3	39	42
harvested	18	..	..	..	..	0	1	30	31
	20	31	29	26	86	0	8	65	73
Sum		104	83	90	277	0	19	222	241
Percent		37.5	30.0	32.5	100.0	0.0	7.9	92.1	100.0
II	May 23	33	24	19	76	0	1	57	58
Machine	26	..	..	..	..	0	3	79	82
harvested	27	29	17	45	91	0	3	51	54
	30	24	25	40	89	0	2	76	78
Sum		86	66	104	256	0	9	263	272
Percent		33.6	25.8	40.6	100.0	0.0	3.3	96.7	100.0
I+II									
Sum		190	149	194	533	0	28	485	513
Percent		35.6	28.0	36.4	100.0	0.0	5.5	94.5	100.0

(a) Data from a single row 100 ft. long in each case. Stands in the two plots were equal.

and were thought to be the result of breakage of longer spears. However, comparison of the two harvest periods in terms of the numbers of pieces falling into the various length of spear classes indicate that such breakage was not an important source of these short pieces. As shown in Table 3, spears or pieces less than 2 inches long averaged 37.5 percent of all spears harvested during the period when the mechanically harvested plot was harvested by hand and breakage was at a minimum, compared to 33.6 percent of all spears in this size class during the succeeding period when spears were actually harvested with the machine from this same plot. It should also be pointed out that cyclic emergence or growth of spears related to method of harvesting was not pronounced.

In addition to reducing yields and quality, use of the machine greatly increased the labor required to sort the usable spears from the stones, straw, weeds and other debris indiscriminately cut off or picked up by the revolving blades of the harvester. Contact with this debris bruised many spears, and long spears which rode the cutting

mechanism several revolutions before dropping into the hopper were further bruised and skinned. The mechanical harvester reduced the time required to harvest a plot, but accurate data on this point were not obtained.

More than a dozen of these mechanical harvesters were employed on commercial farms in Southwestern Michigan in 1960. They were used only for a short time, however, due to the difficulty of sorting the crop from the trash and to the low grades accorded loads at the receiving stations. Several processors complained that the bruising and other types of mechanical damage encountered in the raw product resulted in discoloration of the blanched spears. Equally objectional were the blades of grass which rode the conveyor belts in the processing plant. These were so difficult to remove that they were often found in the packages of whole frozen spears. The proportion of spears suitable for the high quality whole spear pack was, of course, relatively low from mechanically harvested fields.

Non-selective set-level harvesting thus gave low yields of raw product of inferior quality, which in turn resulted in reduced quality of processed product in spite of extra vigilance in handling and packing.

Growth Characteristics of Asparagus Spears

Tiedjens[7] reported that removal of a spear induces the development of adjacent buds which might otherwise remain dormant. Perhaps from this, growers and others[8] have inferred that cyclic production would be induced by mechanical harvesting. No evidence of any such growth pattern has been reported by those working toward the mechanization of asparagus harvesting.

The effects of the removal of tips from spears 4 to 5 inches in length on subsequent elongation are shown in Table 4. Removal of the tip half-inch reduced subsequent elongation about 40 percent, while removal of the tip inch reduced subsequent elongation 87 percent, compared to the controls (Table 4). These statistically significant differences are large enough to have important practical and possibly physiological implications. The effects on yields are obvious, assuming the treatments have no differential effect on number of spears emerging and that increases in spear length are accompanied by com-

[7]op. cit., footnote 6.
[8]op. cit., footnote 1.

TABLE 4—Effects of removal of tips from 4-5 inch spears on growth in 36 hours (Sodus, 1960)

Treatment	Length of spear, inches			Elongation(*a*)	
	Mean**	±	s	Inches	Percent
Not tipped (control)	11.53	±	.74	7.03	156
½ inch of tip removed	8.88	±	.14	4.38	97
1 inch of tip removed	5.41	±	.67	0.91	20

(*a*) Gain over 4.5 inches original length.
** All means significantly different at the 1 percent level of P. Coefficient of variation = 6.8%.

mensurate increases in spear weight. Set-level harvesting did not appear to have any practical effect on the number of spears emerging.

The effects of removal of the tips of spears of various lengths are shown graphically in Fig. 2. Among the untipped spears, those which were 5 cms. long when marked (t_0) showed maximum increase in length in 24 hours in the basal 0-2.5 cm. segment; those which were 10 cms. long at t_0 showed maximum increase in length in this period in the 5.0-7.5 cms. segment, while those which were 15 cms. long at t_0 showed maximum increase in length in the 10-12.5 cms. segment. Thus, the segments just behind the apex are seen to exhibit maximum elongation and to assume increasing importance in elongation as spears grow, while the basal segments contribute correspondingly less to vegetative extension as taller spears are considered. The tip 2.5 cm. elongated less than the two segments below it in normal spears which were 10 or 15 cms. long at t_0.

The removal of the apical portion of the spear affected elongation in every segment, and removing the apical 2.5 cms. retarded subsequent growth more than did removal of 1.25 cms. These data also indicate that more than simply the removal of nodes available for subsequent elongation are involved since all segments of the spear were affected by tip removal, suggesting a growth regulator effect and perhaps the possession of intercalary meristems.

These data clearly demonstrate how tip injury from set-level harvesting drastically reduces subsequent spear elongation, whether the spears injured are 2, 4 or 6 inches in height. Combined with the irregular nature of emergence, the growth characteristics of asparagus spears appear to impose rigid limitations on the yield possibilities of

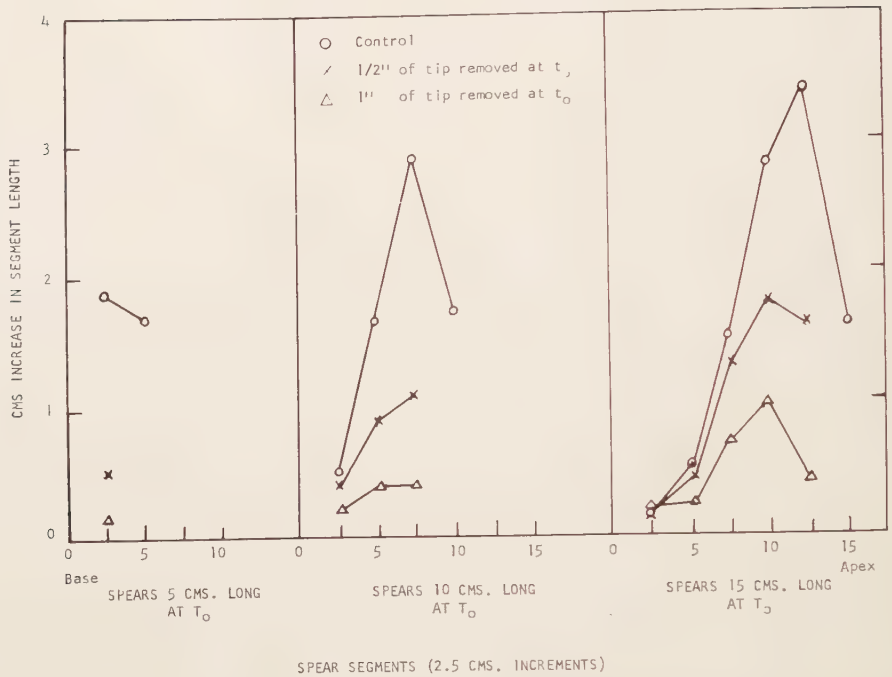

Fig. 2. The effects of removal of the tips of asparagus spears of various lengths on subsequent elongation in each 2.5 cm. segment in 24 hours.

set-level harvesting. Adjusting the height of cut to 4 or 6 inches, however, should be investigated as a means of reducing yield losses from tip injury, although it is evident that, other things being equal, considerable yield reduction would still be encountered with non-selective harvesting.

SUMMARY AND CONCLUSIONS

Two years' results comparing set-level machine harvesting of asparagus with hand snapping showed that the lack of selectivity for length of spear, inherent in set-level harvesting, resulted in 40 to 50 percent lower yields and a significant reduction in quality of the harvested and processed crop.

Set level harvesting showed no tendency to induce cyclic production of spears.

Study of the growth characteristics of asparagus spears indicated that as spears elongate, the basal segments contribute less and less to longitudinal growth, and the rate of elongation per shoot segment

increases progressively toward the apex of the spear. Removal of the tip 2.5 cms. from spears 10 to 15 cms. long reduces subsequent longitudinal extension to about a tenth of that of untreated spears, suggesting that a growth regulator perhaps contributed more or less equally by the remaining young nodes of the "head" or tip of the spear exercises major control over spear elongation.

MECHANICAL HARVESTING AND BULK HANDLING TESTS WITH PROCESSING TOMATOES[1]

By S. K. RIES[2], B. A. STOUT[3], C. L. BEDFORD[4] and M. E. AUSTIN[3]

SEVERAL MACHINERY MANUFACTURERS and universities have developed experimental machines capable of mechanically harvesting tomatoes. Although the principle of operation and the details of construction are different for each machine, all are based on a once-over principle in which the plant is cut near the soil surface and elevated to a separating unit where the fruit is shaken from the plant.

Ries and Stout (5) described the development of a tomato harvester and discussed the problems associated with once-over harvest. They reported tomato yields in 1959 of up to 18 tons per acre.

The Campbell Soup Company (1) illustrated several machines each differing in construction, but based on the once-over harvest principle. Reeder (4) cited the advantages and disadvantages of the machines in general.

The development of machines for mechanical harvesting has influenced the development of bulk harvesting methods. In 1950, MacGillivary *et al* (2) made a bulk handling test in California of transporting tomatoes in water and found that the fruits developed numerous small cracks. Five years later these studies were continued in order to test whether there were advantages greater than the disadvantage of cracking. It was concluded in 1957 that dry bulk handling of tomatoes would save $1.00 per ton of fruit and that water handling would offer no savings. Also, storage in either air or water up to 48 hours decreased the soluble solids of tomatoes; however, water gave the greatest loss. Twigg *et al* (7) also found a decrease of soluble

[1]The authors wish to acknowledge the financial assistance of the Chisholm-Ryder Company for construction of the 1960 machine and the Campbell Soup Company for sponsoring the field research.
[2]Department of horticulture.
[3]Department of agricultural engineering.
[4]Department of food science.

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solids by water handling. Water handling reduced the Drosophila egg count. MacGillivary *et al* (2) observed that mold count values increased with time with dry bulk handling methods, but not with water handling methods.

Many workers (3) (5) (6) (7) (9) (10) have recognized the problems involved in once-over harvest. Tomato varieties with a small vine-to-fruit ratio, concentrated fruit set, and uniform maturing fruit are but a few requirements needed. When to harvest in a once-over operation to obtain the highest yield and quality of tomatoes is a difficult problem facing researchers today. Massey and Peck (3) observed a peak in the maximum yield of ripe tomatoes under one-pick harvest conditions.

The 1959 model Michigan State University mechanical tomato harvester was described in detail by Stout and Ries (6). Although the principle appeared sound, many deficiencies were apparent in performance.

The objectives of this research were to determine: (1) The quality of mechanically harvested tomatoes handled in various types and depths of containers, (2) the effect of once-over harvest on successive dates on the yield and quality of tomatoes, and (3) the yield and quality of several tomato varieties.

The 1960 Machine

A completely new machine was designed and constructed in 1960 incorporating the following major changes:

(a) The main elevator chain was widened from 30 to 48 inches.

(b) The separating bed was widened from 30 to 48 inches and lengthened from 36 to 42 inches.

(c) Provisions were made for a sorting platform where the green or broken fruit and foreign material could be removed manually.

(d) The harvested fruit was gently lowered into containers carried on a separate trailer pulled alongside the harvester.

After the break-in period, when a few modifications were necessary, most of the 1960 tests were devoted to a study of varieties and handling systems.

The basic principle of operation was unchanged from 1959. The harvester was a pull-type machine and was powered by the tractor

power take off. The tomato plants were cut off just below the soil surface. The plants and loose fruits were then elevated to the separating bed where fruits were shaken off. After that they were carried through a series of conveyor belts and across a sorting platform where all but ripe and grade one tomatoes were removed. Then the marketable fruit was gently lowered into a suitable container on a separate trailer or truck. Forward travel speeds ranged between ½ and ⅔ m.p.h.

The pickup mechanism consisted of a straight blade running just below the soil surface. The depth was controlled hydraulically by a remote cylinder regulated by the tractor operator. An overhead gathering chain was mounted above the blade. Steel fingers 7 inches long with 8¼ inches clearance between the ends of the fingers and the blade helped move the plants onto the elevator chain.

The main elevator chain was constructed by welding pipe extensions into standard 30-inch potato chain links to make them 48 inches wide. The pitch of the chain was 1.56 inches.

The tomatoes dropped 8 inches from the main elevator chain onto the separating bed. The bed was made of ½-inch electrical conduit spaced 6⅛ inches on center. It was 48 inches wide and 42 inches long. A 4-inch stroke was used with speeds ranging from 180 to 200 cycles per minute. Overhead fingers carried the plants off the rear of the separating bed where they fell to the ground.

Steel fingers 10 inches long extended down between the conduits in the separating bed. The overhead chain ran at 118 feet per minute. Since the bed was 3½ feet long and reciprocating at 200 cycles per minute, a plant would be shaken 11.8 times if it were carried across the entire length of the bed. Figure 1 is a rear view of the 1960 machine showing the separating unit and the conveyors for elevating and sorting.

A receiving conveyor was located 8 inches below the top of the separating bed and parallel to the plane of the conduits. This conveyor carried the fruit to the right onto the cleaning belt.

The fruit dropped 5 inches onto the cleaning belt which moved up a 30-degree slope. Some dirt and trash were discharged from the top while the fruit rolled down the slope onto a grading chain.

A grading chain with 1⅞-inch openings carried the fruit to the left of the machine. Small fruits were permitted to drop onto the ground.

Fig. 1. A rear view of the 1960 M.S.U. tomato harvester showing the separating unit and the conveyors for elevating and sorting tomatoes.

The fruit dropped 5½ inches from the grading chain onto the lower horizontal conveyor. This conveyor carried it forward to the 45-degree conveyor.

The fruit descended 3 inches onto the 45 degree conveyor. This belt had 1½-inch flights on 12-inch centers, and carried the fruit after a fall of 4 inches to the top horizontal conveyor which served as a sorting table. The belt on the sorting table was 18 inches wide and moved at 86 feet per minute.

The fruit fell 3 inches onto a counter-balanced lowering conveyor with 2-inch flights on 8-inch centers. The discharge end was movable to any position from 3 to 10 feet above the ground. It could be easily controlled by the operator on the trailer. The fruit was gently lowered into suitable containers. The sorting platform and lowering conveyor are shown in Fig. 2 along with the boxes that were used to study handling systems.

TESTS OF INJURY ON MACHINE COMPONENTS

Method

Spot checks were made to determine where injury occurred on the machine. The machine was operated normally, stopped and

samples of 20 ripe fruits from each component were examined and the fruit with cracks greater than 1 inch in length counted. This was done with three varieties, Fireball, Libby C-52, and Heinz 1370. The latter two were examined on the same day in adjacent plantings.

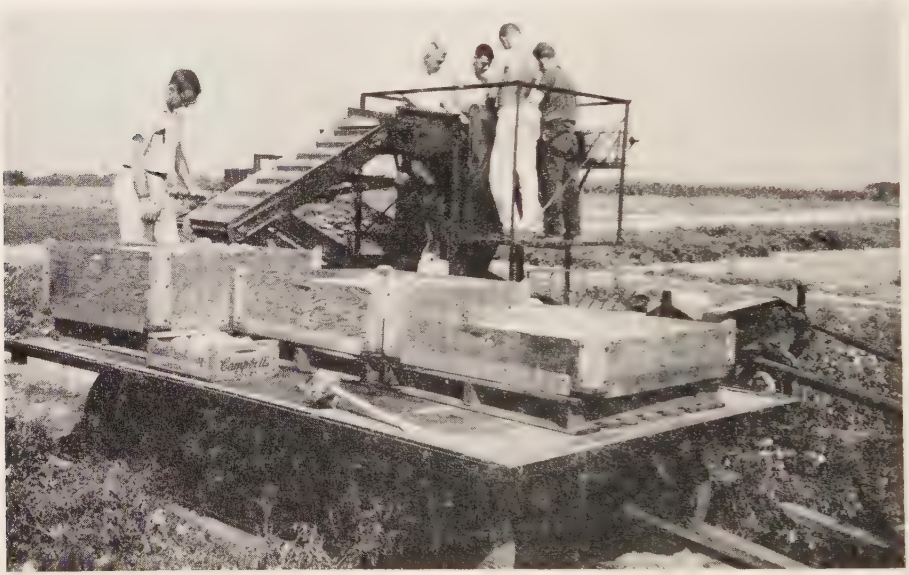

Fig. 2. Side view of machine and trailer showing grading area, lowering conveyor and the boxes that were used to study handling systems.

Results

Table 1 shows injury occurring from the different components, and indicates that the mechanical removal of fruit from the vine and the resultant drop to the conveyor increased cracking about 8 percent. There was no consistent additional injury caused by the remaining components until the fruit dropped into the container.

STUDIES OF MECHANICAL HARVEST AND HAND HARVEST INTO BULK BOXES, LUGS, AND WATER

Methods

The bulk boxes used were 45 inches long, 43 inches wide and 8, 12 and 16 inches deep. Assuming a bulk density for tomatoes of 36 pounds per cubic foot (California unpublished data), the bulk boxes would hold 323, 484, and 646 pounds of tomatoes, respectively.

TABLE 1—Average injury to three tomato varieties from various components of M.S.U. harvester. (Expressed in percent of fruit with cracks over 1 inch long)

Components	Distance of drop to component (inches)	Injury (percent)
Main elevator chain	..	8.9**
Conveyor below separating bed	8	16.7
After leaving cleaning belt	7	18.8
45° elevator to sorting belt	3	15.5
Sorting belt	4	17.7
Lowering conveyor	3	21.6
Container	12	28.8**

** The F. value for comparison of these means with all others significant at 1 percent level. There is no difference between other means.

The empty boxes weighed 78, 87, and 99 pounds, respectively, and the pallet 67 pounds. In one experiment, the actual tomato weight in the bulk boxes was 320, 486, and 634 pounds, respectively.

Table 2 gives the conditions under which each test was conducted. In each test the weights of crushed fruit, and fruit having cracks over 1 inch were recorded for each sample.

In test I, III and VI, tomatoes were harvested by hand and by machine, and loaded directly into 8-, 12- and 16-inch deep bulk boxes. Fruits were also harvested into lugs and polyethylene lined 12-inch bulk boxes with 4 inches of water. Each bulk box was divided, one-half being filled by machine and the other with hand picked fruit. All treatments were taken for a 20-mile truck ride in tests I and III. On test VI, they were taken for a trailer ride around the farm.

In test II, tomatoes were harvested by hand and by machine directly into 12-inch bulk boxes. Half of the bulk box contained 4

TABLE 2—Conditions under which different tests were conducted

Test	Variety	Harvest date	Sampling time (hours after harvest)	Rainfall	Temperature (F.)		Replications
					Max.	Min.	
I	Fireball	9/1	24	Trace	91	71	2
II	Fireball	9/6	24, 48 and 72	Trace	94	54	3
III	Fireball	9/12	24	None	75	51	2
IV	Fireball	9/14	2 and 24	None	72	36	2
V	Fireball	9/15	24	None	75	52	3
VI	Libby C-52	9/22	24	None	74	59	2

inches of water, and the other half was dry. The tomatoes were taken for a 20-mile ride and returned to the field before sampling.

In test IV, the tomatoes were harvested by hand and by machine, into lugs, and 8- and 12-inch deep bulk boxes. They were then taken for a 20-mile ride.

In test V, ripe fruits were harvested by machine into lugs, and 8- and 12-inch deep bulk boxes. Fruits were hand harvested only into lug boxes.

A factorial analysis was made of tests I, III and VI, using a split plot design with three dates, two methods of harvest, three depths of bulk boxes and two replicates.

The remaining three experiments (II, IV and V) were analyzed individually as factorial designs. In each case, the factorials were partitioned into individual degrees of freedom in the analysis of variance. Linear and quadratic effects were determined in each test where 3 depths of boxes were used or 3 times of sampling included.

Each sample from these bulk handling tests was taken to the Food Science Laboratory immediately. The following determinations were made:

Juice Yield. The tomatoes were weighed, washed, drained, cut into pieces, heated to 185° F. in a stainless steel kettle, transferred to a juice extractor with a .033-inch screen and the resulting juice was weighed.

Canned puree. The juice was concentrated in a stainless steel jacketed kettle to a soluble solids content of 8.5 - 9.0 percent, filled hot into No. 303 cans, sealed, inverted for 10 minutes and cooled in cold running water.

Total solids and soluble solids.[5] 10 g. of the sample was weighed into a tared aluminum dish. The sample was dried for 8 hours at 70°C. under 28 inches of vacuum and a slow stream of dried air. Soluble solids were determined with an Abbé refractometer.

Color. Gardner L, a and b readings were obtained using a 2″ x 1½″ sample cell and the mirrors in the "L" position. The instrument was standardized with a red porcelain plate having the values of L 24.1, al 27.4, bl 12.5.

Molds.[5] Mold counts were made according to official methods described in the A.O.A.C. 8th edition.

[5]The authors gratefully acknowledge the assistance of A. H. Hafner for mold counts and solids determination.

TABLE 3—Tomato handling experiments. (Average observations from all tests which were sampled after 24 hours)

Method of harvest	Container	Depth	Sample(*a*)	Cracks over 1 inch	Crushed fruit	Juice yield	Soluble solids	Total acidity as citric	Color gardner	Total solids Soluble solids	Mold count
		Inches		Percent	Percent	Percent	Percent	Percent	a/b	Ratio	Percent
Hand	Lug Box	5	..	8	0	81	4.4	.264	2.00	1.09	9
	Bulk Box	8	T	6	0	84	4.6	.294	2.04	1.08	12
	Bulk Box	8	B	14	2	78	4.6	.286	2.00	1.11	7
	Bulk Box	12	T	6	0	82	4.8	.292	2.05	1.10	12
	Bulk Box	12	B	17	1	80	4.7	.277	2.05	1.17	5
	Bulk Box	16	T	8	0	80(*b*)	5.4(*b*)	.297(*b*)	....	....	..
	Bulk Box	16	B	18	2	82(*b*)	5.8(*b*)	.306(*b*)	....	....	..
	Average..	..	..	11	1	81	4.9	.288	2.03	1.11	..
Machine	Lug Box	5	..	30	2	77	4.4	.289	2.05	1.08	8
	Bulk Box	8	T	22	1	76	4.5	.275	2.00	1.07	10
	Bulk Box	8	B	37	3	78	4.6	.277	2.02	1.09	5
	Bulk Box	12	T	18	1	78	4.4	.268	2.00	1.13	12
	Bulk Box	12	B	45	3	76	4.6	.264	2.00	1.11	6
	Bulk Box	16	T	21	2	81	4.8	.322	....	1.12(*b*)	0(*b*)
	Bulk Box	16	B	45	10	78	4.7	.290	....	1.14(*b*)	0(*b*)
	Average..	..	..	31	3	78	4.6	.284	2.01	1.09	..

(*a*) Sample level "T" for top 4 inches, "B" for bottom 4 inches.
(*b*) Average of only 1 test with Libby C-52.

pH and total acidity. These determinations were made with the juice using a Beckman glass electrode pH meter. Ten g. samples were weighed into 250 ml. beakers and 100 ml. of distilled water was added. The resulting mixture was titrated with O.1N NaOH until it reached pH 8.0. The mixture was continuously stirred using a magnetic stirrer. The results were reported as percent citric acid.

Results and Discussion

The mechanical harvest of tomatoes with the Michigan State University machine into all types of containers resulted in two to three times as much injury as hand harvest. This injury, in general, expressed itself as more cracked fruit and about 3 to 4 percent less juice yield, as can be seen in Table 3 which shows the average observation from all tests sampled after 24 hours. Table 3 also shows that there was very little crushed fruit resulting from mechanical harvest. The one outstanding exception was the 10 percent crushed fruits in the samples taken from the bottom 4 inches of the 16-inch deep bulk box.

The least amount of injury occurred from hand harvest into lug boxes. The results of three tests using three depths of boxes are shown in Tables 4 and 5. As the depth of box increased, fruit injury increased for both hand and machine harvested fruit. This uniform increase in injury as the depth of box increased was greater for machine harvested fruit than for hand harvested fruit. In other words,

TABLE 4—The injury occurring due to harvest methods at three different times into three depths of boxes. (Injury expressed as percent of fruit with cracks over 1 inch long)

Depth of bulk box	Harvest method(*a*)		Average(*b*)
	Hand	Machine	
Inches	Percent	Percent	Percent
8.....	11.1	22.1	16.6
12.....	12.8	30.2	21.5
16.....	13.0	33.0	23.0
Average(*c*)....	12.3	28.4	....

(*a*) The F. value for the interaction of depth and harvest method significant at the 1 percent level. This interaction was a linear response.
(*b*) The F. value for the linear response of cracking with depth is significant at the 1 percent level.
(*c*) The F. value for this comparison is significant at the 1 percent level.

TABLE 5—The effect of method of harvest at three different times on injury at different sampling depths. (Injury expressed as percent of fruit with cracks over 1 inch long)

Sample depth	Harvest method(*a*)	
	Hand	Machine
	Percent	Percent
T (Top 4")	5.1	13.2
B (Bottom 4")	13.3	29.4

(*a*) The interaction of sample depth and method of harvest is significant at the 1 percent level.

there was a greater amount of injury when the machine dumped the fruit into deeper boxes than when they were dumped by hand from lugs into the bulk boxes.

The samples from the bottom 4 inches of all containers were injured more than from the top 4 inches, and there was a greater increase in injury from the top to the bottom when harvested mechanically than when hand harvested.

The analysis of test II indicated that more injury occurred when hand harvested tomatoes were placed in water than when handled dry. No difference was found between the two methods of handling the machine harvested fruit. However, there was more total injury to machine harvested fruit handled either way (Table 6). As the time of sampling increased from 24 to 72 hours, the injury expressed as cracks greater than 1 inch increased proportionately, as shown in Table 7. As can be seen in Table 8, the juice yield was appreciably higher for hand harvested fruits for all tests.

The mold count increased rapidly and in the fruit held for 72 hours, it had reached an unacceptable level. Also, the fruit had developed an off-odor. The differences between the handling methods were not significant. The holding of the tomatoes had no effect on the color or total solids/soluble solids ratio of the processed product. The yield of juice decreased as the time of sampling increased from 24 to 72 hours. This linear decrease was greater with tomatoes handled in water than when handled dry. (Table 9).

In test VI, the juice yield was 82 percent for all treatments that were hand harvested, and 79 percent for all machine harvested samples. This difference was significant at the 1 percent level. There was no effect of any other treatment on juice yield.

TABLE 6—The effect of method of harvest on injury when harvested into dry boxes or water. (The average of three sampling dates, injury expressed as percent of fruit with cracks over 1 inch long)

Media	Method of harvest(*a*)	
	Hand	Machine
	Percent	Percent
Dry	21.3	58.8
Water	37.5	56.7
Average(*b*)	29.4	57.8

(*a*) The F. value for interaction of method and media significant at 5 percent level.
(*b*) The F. value for this difference significant at 1 percent level.

In test IV, the tomatoes processed 2 hours after harvest had no fewer cracks and the quality was no better than those processed after 24 hours. This may have been due to the rather cool weather at the time of the test. However, the juice yield was 80 percent for hand harvested fruit, compared to 76 percent for machine harvested samples.

TABLE 7—The effect of time of sampling and the level of where the sample was taken on fruit injury. (Injury expressed as percent of fruit with cracks greater than 1 inch long)

Time of sampling after harvest	Level of sample (*a*)		Aver-age(*b*)
	Top 4 inches	Bottom 4 inches	
Hours	Percent	Percent	Percent
24	19.6	33.1	26.4
48	39.1	56.9	48.0
72	44.8	67.9	56.4
Average(*c*)	34.5	52.6	....

(*a*) The F. value for the different responses of times with sampling depths significant at 5 percent level.
(*b*) The F. value for linear effect as time increased significant at 1 percent level.
(*c*) The F. value for the comparison of means significant at 1 percent level.

TABLE 8—The effect of method of harvest on juice yield in Test II

Harvest method	Juice yield(*a*) (Average of all plots)
	Percent
Hand	76.3
Machine	69.8

(*a*) The F. value for this difference is significant at the 1 percent level.

In test V, where the bulk boxes were used without dividers, there was no difference in fruit injury between the 8- and 12-inch depths. The injury was 36 and 33 percent, respectively, for cracks over 1 inch in length, and 2 and 1 percent, respectively, for the crushed fruit. Machine harvest into lugs resulted in no crushed fruit and only 10 percent cracks over 1 inch.

None of the bulk handling treatments caused any significant change in soluble solids, pH, total acidity, color or total solids/soluble solids ratio. The mold count tended to be lower in the bottom 4-inch sample. This could be due to the removal of the damaged fruit during washing.

TABLE 9—The effect of time of processing and media at different times on juice, yield, mold count, color and total solids/soluble solids ratio

Time processed (hours after harvest)	Juice yield(*a*)		Average(*b*)	Mold count		Gardner color		Total solids Soluble solids	
	Dry	Water		Dry	Water	Dry	Water	Dry	Water
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Ratio	
24	78.5	76.8	77.7	11	6	2.02	2.01	1.10	1.09
48	76.3	69.5	72.9	18	15	2.03	2.04	1.13	1.14
72	73.5	64.0	68.7	30	40	2.08	2.08	1.14	1.12

(*a*) The F. value for the different linear responses of time with the two medias significant at the 1 percent level.
(*b*) The F. value for the linear response of a decreased juice yield with time significant at the 1 percent level.

All of the preceding data are comparative, but the objective observations were made on fruit with cracks greater than 1 inch in length. This type of cracking after harvest has been observed exten-

sively on fruit harvested by hand into lugs or hampers and shipped to commercial processing plants. It is difficult to make a comparison of the results of these tests with commercial harvests because of the wide variability found in the field and also the discrepancy in opinion regarding the severity of this type of cracking for commercial processing. Observations were also made on crushed fruit which was so small in most cases that it did not appear significant.

Since such a small percentage of crushed fruit resulted from most treatments, it would seem feasible to use bulk boxes that are about 12 inches deep for handling tomatoes. Further refinements on machines to handle the tomato more gently will be advantageous.

EFFECT OF TIME OF ONCE-OVER HARVEST ON YIELD AND QUALITY OF TOMATOES

Method

Uniform plantings of the varieties Fireball and Libby C-52, which were transplanted June 7, were divided into 15 plots each and assigned five harvest dates with three replicates each. On these dates, a simulated mechanical harvest was made by hand and the total amount of ripe, green and deteriorated fruit determined. Samples were also processed for each variety at each harvest date.

Results

Both varieties responded similarly, as can be seen in Table 10. The yield of ripe fruit reached a peak on September 12, and did not change for three harvests over an 11-day period. The percentage of green fruit decreased over this period and the percentage of deteriorated fruit increased.

The most important result was that although the yield of ripe fruit did not decrease, the juice yield did decrease, as did the total acidity. The pH increased, the soluble solids and total solids/soluble solids ratio did not change. The color was poorer at the first harvest than in the following harvests. No marked variation occurred in color until the last harvest when there was a definite increase in the a/b ratio. The mold count tended to reach a peak on September 12 and then decreased. There was also a change in the mold type, going from fine hyphae to thick hyphae as the season progressed.

TABLE 10—Effect of time of once-over harvest on yield and quality of tomatoes

Variety	Harvest date	Ripe fruit	Green fruit	Deteri-orated fruit	Juice yield	pH	Total acidity (as citric)	Soluble solids	Color gardner	Total solids Soluble solids	Mold count
		Tons per acre			Percent		Percent	Percent	Percent	Ratio	Percent
Fireball.....	9/1	8.3	27.0	1.3	79.8	4.25	.288	5.0	1.72	1.10	2
Fireball.....	9/6	16.0	17.4	4.6	82.2	4.30	.244	...	1.97	1.14	6
Fireball.....	9/12	27.4	7.0	3.4	82.6	4.10	.282	5.1	2.03	1.10	8
Fireball.....	9/15	27.5	2.9	5.4	78.9	4.15	.256	5.0	2.01	1.10	4
Fireball.....	9/22	27.4	2.9	11.6	77.8	4.30	.244	5.1	2.21	1.11	0
LSD at 5 percent..	....	10.0	2.7	2.5							
LSD at 1 percent..	....	14.1	3.7	3.5							
Coefficient of Variation (Percent)	....	24	14	29							
C-52.....	9/1	5.0	24.7	.4	84.2	4.05	.371	4.8	1.94	1.10	2
C-52.....	9/6	11.3	12.0	.9	81.5	4.00	.397	4.6	2.04	1.12	0
C-52.....	9/12	22.3	8.6	2.2	81.9	4.05	.345	5.6	2.07	1.12	16
C-52.....	9/15	25.6	6.4	2.0	76.2	4.10	.364	5.0	2.06	1.10	0
C-52.....	9/22	24.5	4.2	6.4	79.4	4.35	.320	6.0	2.23	1.08	4
LSD at 5 percent..	....	7.3	1.7	2.2							
LSD at 1 percent..	....	10.2	2.4	3.1							
Coefficient of Variation (Percent)	....	21	10	59							

VARIETY TRIALS

Methods

Four variety trials were established. The first test, transplanted in the field on May 17, consisted of only four varieties. These were used to test the machine and replicated records were not obtained. The last trial, transplanted June 16, was frozen on October 1.

By the time the harvests were made in the second trial, the machine was working nicely and no major changes were made for the remainder of the season.

Each plot in the variety trials was harvested exactly alike. Since maturity was not uniform, it was not practical to operate the harvester down the row because injury would have occurred to adjacent unharvested rows. All plots were harvested by pulling the plants by hand and placing them on the main elevator chain of the machine. The ripe, green and deteriorated fruit left on the ground, on the plant, and removed by the machine were all weighed. In the tables, the fruit left on the ground and that removed by the machine, are combined. Those left on the plants after harvesting were not included in this total, but expressed as percentage of the total yield as is the fruit that was left on the ground. The time of harvest was decided arbitrarily as that time when it "seemed" like more fruits were starting to deteriorate than were ripening.

After harvesting, a 30-pound composite sample of each variety was collected and processed into a puree within 24 hours. The juice yield, pH, soluble solids and total acidity were measured when the samples were processed.

Observation plots on 24 other varieties were also transplanted on June 7, but none appeared to be as good as those in the replicated trials.

Results

The results of the variety trial are presented in Tables 11 and 12. Of the varieties tested, the following offer the most promise for mechanical harvest in Michigan. Libby C-52 is probably the best variety because of its concentrated fruit set, high yields, early maturity and good processing quality. However, C-52 is soft, and does crack. Fireball is consistently early and yields well under adverse conditions. It is softer and cracks more easily than other standard processing varieties. Cornell 54-149 was as early or earlier than Fireball,

TABLE 11—Summary of variety trial II. Seeding date—April 13. Transplanted in greenhouse—April 28. Transplanted in field—May 27. Plot size—15 plants spaced 5 x 2

Variety	Mechanical harvest date	Four hand harvests	Machine harvest yield			Fruit ripe on ground	Fruit on plant	pH	Processing evaluation		
			Ripe	Green	Deteriorated				Soluble solids	Juice yield	Total acidity
		Tons per acre				Percent	Percent		Percent	Percent	
Fireball	8/25	30.9	16.8	12.9	3.3	38	2	4.50	4.0	60.0	.265
Libby C-52	9/6	31.2	22.5	6.6	5.6	12	9	4.20	3.5	68.0	.269
Epoch(*a*)	9/6	20.6	11.2	17.4	1.3	26	7	4.00	5.0	81.1	.320
Birdnest(*a*)	9/2	15.7	9.3	9.5	1.8	39	4	4.20	4.2	81.6	.320
Maryland 314	9/2	32.7	14.9	17.6	3.2	23	4	4.10	5.0	74.3	.313
Heinz 24	9/6	36.7	20.0	28.7	2.4	19	9	4.15	4.1	87.7	.326
Harris 7549	8/29	33.6	19.7	20.2	4.1	35	2	4.30	5.0	79.7	.361
OSC 327	8/31	28.9	18.3	19.1	3.8	22	8	4.30	5.0	75.5	.262
OSC 435-4	9/2	42.3	18.7	21.0	2.8	26	6	4.10	5.0	85.1	.288
Cornell 54-149	8/25	34.6	16.1	12.9	2.1	20	6	4.50	4.0	77.1	.326
Cornell 59-389	8/31	25.6	8.6	20.1	4.5	30	6	4.20	4.9	83.5	.320
Tanggula	8/31	27.5	14.7	26.5	4.3	24	4	4.20	4.9	90.6	.307
M.S.U. 41-3A	9/2	39.9	18.3	22.1	4.0	20	5	4.15	5.1	82.1	.262
LSD at 5 percent	....	6.2	4.4	7.4	NS	12	1				
LSD at 1 percent	....	8.7	6.1	10.4	NS	NS	NS				
Coefficient of variation (Percent)	....	9.3	12.4	18.8	51.3	22.3	10.9				

(*a*) These varieties were spaced 5 x 1 instead of 5 x 2.

TABLE 12—Summary of varieties which were only mechanically harvested in variety trial III

Variety	Harvest date (Sept.)	Yield			Fruit ripe on ground	Fruit on plant	Processing evaluation			pH	Color gardner	Total solids Soluble solids
		Ripe	Green	Deteri-orated			Juice yield	Soluble solids	Total acidity (as citric)			
		Tons per acre			Percent	Percent	Percent	Percent			a/b	Ratio
Fireball	12	33.8	6.0	3.2	31	4	80.0	5.1	.313	4.25	2.04	1.12
Libby C-52	14	26.7	7.1	1.2	15	12	78.0	5.0	.410	4.05	2.07	1.10
Epoch	26	14.0	6.3	3.8	30	16	81.5	5.1	.352	4.30	2.08	1.05
Birdnest	21	9.9	1.8	3.0	71	6	81.5	4.8	.326	4.40	2.10	1.10
Maryland 314	21	26.2	6.1	1.2	34	6	82.6	5.5	.435	4.20	2.28	1.09
Heinz 24	26	31.9	20.2	5.2	42	8	80.9	5.2	.390	4.30	2.06	1.11
Harris 7549	12	32.1	11.9	2.4	40	6	82.4	5.1	.352	4.15	2.07	1.11
OSC 327	14	25.5	13.9	2.7	29	8	84.5	5.1	.403	4.15	2.08	1.10
OSC 435-4	14	28.4	13.2	1.1	20	3	84.5	5.6	.390	4.15	2.15	....
Cornell 54-149	6	19.5	8.7	1.8	15	6	83.5	4.5	.416	4.10	2.02	1.10
Tanggula	21	29.7	10.1	3.7	34	6	82.0	5.1	.409	4.40	2.23	1.07
M.S.U. 41-3A	21	28.7	6.6	5.1	34	6	80.9	4.5	.339	4.30	....	....
LSD at 5 percent	..	7.7	4.7	3.6	14	5						
LSD at 1 percent	..	10.4	6.3	4.9	19	7						
Coefficient of variation (percent)	..	13.1	26.1	42.7	17.0	38.4						

had fair processing quality and a concentrated set of small fruit. OSC 435-4 matured in midseason, had a concentrated set of large fruit and good processing quality.

There were some variations in the color of the puree. However, the differences were not great enough to make any decision as the most suitable colorwise for processing.

From this experience of evaluating a relatively few tomato varieties for mechanical harvest, it is apparent that it is important to limit the number of varieties in any trial which precludes large scale testing because of the many observations necessary. To the authors' knowledge, the preceding varieties are not resistant to the diseases fusarium and verticillian wilt, which would be necessary for a new variety introduced in many production areas. It should also be stressed that these results were obtained under ideal environmental conditions for tomato growth and are from only one location.

SUMMARY

The third Michigan State University mechanical tomato harvester model since 1958 was constructed and tested in 1960. The major changes incorporated in the 1960 model were (1) the width was increased from 30 to 48 inches; (2) a sorting conveyor and platform accommodating up to six men was added; and (3) a device was added which enabled the harvested fruit to be gently lowered into bulk boxes on a separate trailer pulled alongside the harvester.

After this machine was tested and modified in Florida and on early transplants in Michigan, no further major changes were necessary during the remaining season's research.

The mechanical harvest of tomatoes with the Michigan State University machine into lugs and 8- and 12-inch deep bulk boxes caused no appreciable increase in crushed fruit, compared to hand harvest. However, cracks over 1 inch long were two to three times as great for mechanical harvest compared to hand harvest. The juice yield was 3 to 6 percent less for mechanical harvest than for hand harvest into all types of containers.

As the depth of box increased, the fruit cracks greater than 1 inch long increased. This increase was greater for machine than for hand harvested fruit. The samples from the bottom 4 inches of all containers had more cracks than those from the top 4 inches.

Water handling was no better than dry handling and the quality was appreciably lower if the tomatoes were held longer than 24 hours.

The handling methods did not affect the pH, acidity, soluble solids, total solids/soluble solids ratio, color or mold count. Based on this single year's experience, the 12-inch deep bulk box appeared to be the most practical container for handling machine harvested tomatoes.

Simulated once-over harvest over a 3-week period indicated that both Fireball and C-52 responded the same. The total ripe yield reached a peak and maintained this peak for 10 days, however, during this period there were more deteriorated fruit and the juice yield decreased.

In the replicated variety trials, the following varieties look most promising when grown under East Lansing conditions: Cornell 54-149 and Fireball for early varieties; Libby C-52 and OSC 435-4 for mid-season; and Heinz 24 for a late variety.

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CONSUMER RESPONSE TO FROZEN MEAT

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INTRODUCTION

Sale of frozen meat in the past few years usually has not been successful.[1] Many packers and retail stores have discontinued or drastically reduced their frozen meat operations to specific cuts (such as frozen beef patties) for which consumer demand was higher.

From a survey of 4,000 households in Flint and Grand Rapids, Michigan made by Riley[2], it was concluded that most consumers believe they prefer fresh beef to frozen beef. In a later study by Higgins and Riley[3], involving 436 households in a suburban residential area surrounding Detroit, 42.9 percent of those interviewed stated that they preferred fresh meat to the frozen meat. Only 8 percent stated a preference for frozen meats.

The introduction of centralized meat processing plants may bring renewed interest in the possibilities of selling frozen meat. Meat which is overwrapped and properly frozen is particularly adaptable to centralized operations. The problems of shelf life, rewrapping and package fogging, inherent in fresh meat, do not exist with frozen meat. Properly frozen meat can be transported considerable distances from processing plant to retail stores without affecting the color, which is so essential to consumer acceptance.

This is a case study of a supermarket in Toledo, Ohio that has been selling frozen meat for more than 13 years. The supermarket is a two-store operation with annual meat sales of approximately 700,000 pounds. The meat is all frozen, overwrapped in opaque paper and displayed in conventional meat cases.

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[2] Riley, Harold (August 1956). What consumers are saying about prepackaged frozen meats. Mich. Agr. Expt. Sta. Quart. Bul. 39: 36-41.

[3] Higgins, Glen W. and Harold M. Riley (May 1959). Consumer attitude and behavior towards frozen meat. Mich. Agr. Expt. Sta. Quart. Bul. 41: 894-904.

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Shoppers were interviewed at the two stores and in the vicinity of one of the stores, in an attempt to determine the acceptability of frozen meat by those customers who have a convenient opportunity to buy it.

OBJECTIVES OF THE STUDY

In view of the reported general preference for fresh meat, it was deemed worthwhile to examine this example of a successful frozen meat business.

Specifically, the objectives were to find out:

1. What techniques the supermarket has used in merchandising frozen meat.
2. What degree of consumer acceptance of frozen meat is indicated by clientele of the supermarket.
3. What degree of consumer acceptance of frozen meat is indicated by residents of the immediate vicinity of this particular supermarket who have an opportunity to purchase frozen meat at a supermarket.
4. What objections to frozen meat remain after consumers have an opportunity to use a full line of commercially frozen meat.
5. Whether the acceptance of frozen meat at the stores studied indicate that similar techniques can be used successfully by other retail stores as a means of implementing centralized prepackaging operations.

METHODOLOGY

The study consisted of interviews with three segments of the population: (a) 260 shoppers at the larger store, (store No. 1), (b) 129 shoppers at the smaller store, (store No. 2), and (c) 251 families living in the vicinity of the No. 2 store. The sampling techniques used for (a) and (b) were to select the second customer who entered the store after the preceding interview was completed. If the customer refused to complete the interview, the interviewer returned to the front of the store and selected the second customer to enter the store.

For group (c) every second home, or apartment in the case of multiple family units, was selected in a 5-square-block area north of the No. 2 store. The first family interviewed on each street was

selected so that there would not be an unusually high number of families living on corner lots. The interviews were conducted between November 1 and December 16, 1960.

CHARACTERISTICS OF THE MARKET

The supermarket studied in Toledo, Ohio is a two-store operation. The larger store has approximately 5300 sq. ft. of display space, 736 sq. ft. of meat processing area, and approximately 300 sq. ft. of vegetable processing area. This is store No. 1 and has been operated as a supermarket in which frozen meat (except delicatessen meat) has been sold for 13 years. Prior to that time, the management operated a locker plant at the same location and was widely known for the high quality of meat sold. Frozen food lockers are still maintained at the store and the processing of meat for locker owners and home freezer owners is still done at the store. As the locker evolved into a supermarket, many of the former customers continued to buy meat from the firm.

The No. 2 store is located approximately 5 blocks from the No. 1 store. It has 3440 sq. ft. of merchandising area and 860 sq. ft. used for storage and vegetable processing. Frozen meat is centrally processed at the No. 1 store and delivered to the No. 2 store as needed.

The characteristics of the areas surrounding the two stores appeared to be different. The No. 1 store is located on the fringe of a high income area of Toledo. The No. 2 store is in a middle income area of the city. While it is only 5 blocks from the No. 2 store, the No. 1 store is located between the No. 2 store and the high income residential area of the city. The residents of the higher income area prefer to shop at the No. 1 store because it is more convenient and has a more complete line of groceries. The No. 2 store draws almost exclusively from the middle income area surrounding the store, and has been in operation for only 5 years.

Meat Processing Methods Used

The owner of the supermarkets sells what he describes as four grades of beef, veal and lamb.[4] These grades are USDA Good, USDA Choice, USDA Prime and the market's Super Deluxe, which is described as show beef or show lamb of superior quality. The

[4]Pork is also sold but is not graded.

beef sold to the market is all aged for a period of approximately 17 days at the packing house before being delivered to the store.

As the meat is received at the No. 1 store, it is processed into the retail cuts, trimmed, vacuum packaged, overwrapped with non-transparent paper and blast-frozen at —40° Fahrenheit. Attempts are made to cut and trim unformly so that once the housewife has used the meat she will know the size and the amount of bone and fat on specific cuts even though she cannot see it. The amount of bone and fat left on some common cuts of beef and pork are shown in Figs. 1-3.

The meat is merchandised in conventional frozen food cases similar to those used in self-service supermarkets, except that the freezing unit has a higher capacity compressor. The meat is separated in the cases by grade and by type of cut. Identifying signs are used to direct the consumer to the various grades and cuts of meat.

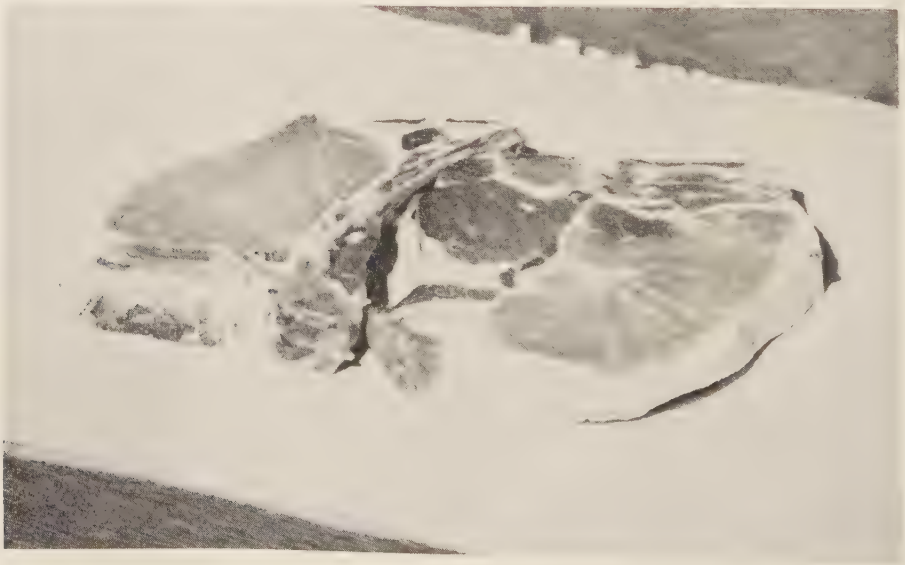

Fig. 1. Pork chops trimmed and ready for vacuum packaging, overwrapping and blast freezing at −40°.

Characteristics of Those Interviewed

Characteristics of the 640 individuals interviewed in this study, in regard to age, income, distance traveled to the store and frozen storage facilities available at home, are shown in Tables 1, 2 and 3 and Fig. 4.

Fig. 2. USDA Prime Porterhouse Steak after being trimmed for the frozen package.

It is evident from Table 3 that the No. 1 store draws customers from a wide area of the city. More than 10 percent of those interviewed in the No. 1 store traveled 5 miles or more one way to shop at the market; some traveled more than 20 miles.

TABLE 1—Age of male head of family

Age	Shoppers in store number 1	Shoppers in store number 2	Residents in the area of store number 2
	Percent	Percent	Percent
Less than 30 years	3	5	12
30-40 years	31	39	24
41-50 years	33	19	22
51 and over	28	31	36
No rep y	5	6	6
Total	100%	100%	100%
Total number	260	129	251

CONSUMER REACTION TO FROZEN MEAT

The proportion of meat purchased from the stores by those interviewed in the No. 1 store was higher than at the No. 2 store or in the residential area surrounding the No. 2 store.

Since the stores offer only frozen meats, it was not surprising to find that a considerable portion of shoppers interviewed in the stores purchase frozen meat. The percentage of those residents living in the area of store No. 2 purchasing over ¼ of their meat supplies in

Fig. 3. A 2-lb., 4-oz. USDA Prime Pin Bone Steak before trimming. After trimming (below) are a 12-oz. New York steak, a 2½-oz. fillet mignon, 6 oz. of stew meat and 15½ oz. of bone and fat.

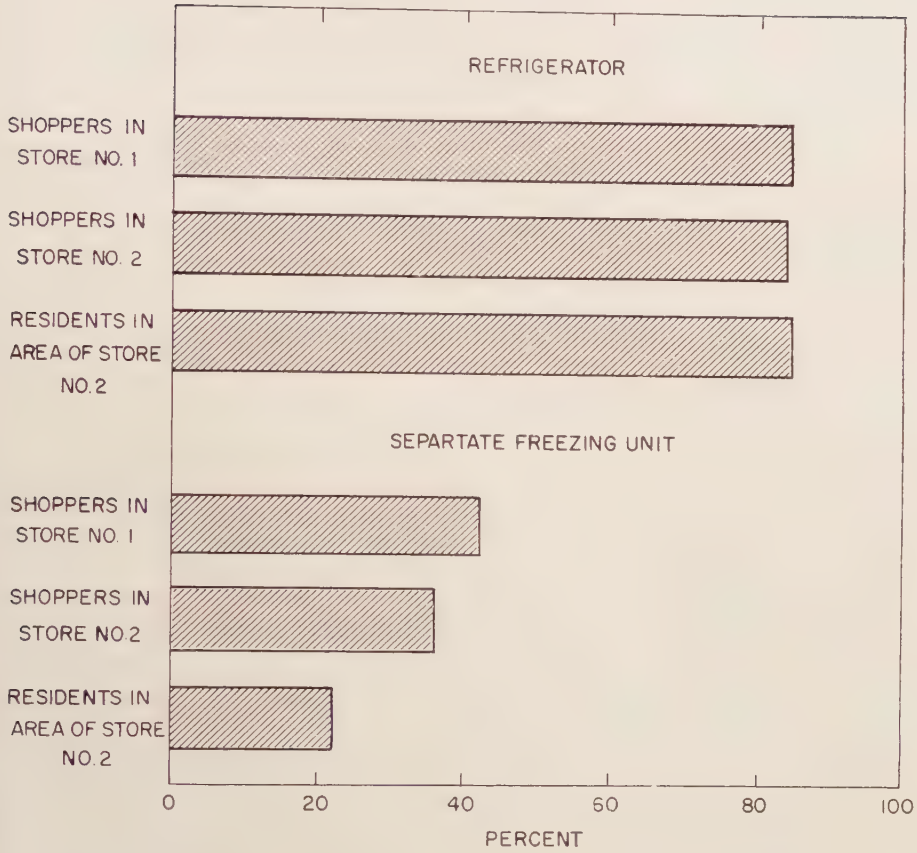

Fig. 4. Percentage of those interviewed who possessed a separate freezing unit and frozen storage space in their refrigerators.

TABLE 2—Total family income of those sampled

Income	Shoppers in store number 1	Shoppers in store number 2	Residents in the area of store number 2
	Percent	Percent	Percent
Less than $4,000 per year	0	0	7
$4,000- 5,000 per year	2	14	13
$5,000- 7,000 per year	4	12	27
$7,000- 10,000 per year	19	35	21
Over $10,000 per year	72	37	10
No reply	3	2	22

TABLE 3—Distance one way from home to store of those interviewed

Distance	Shoppers in store number 1	Shoppers in store number 2	Residents in the area of store number 2
	Percent	Percent	Percent
0-4 blocks	14	51	66
4-8 blocks	18	23	15
Over ½ mile	68	26	19

the frozen form was quite low and indicates a lack of acceptance of frozen meat in this area.

A large part of the difference in acceptance of frozen meat between stores No. 1 and No. 2 may be explained by differences in the two stores and the areas in which the stores were located.

TABLE 4—Purchases of frozen meat as a percentage of total meat purchases in the 30 days prior to the interview

Percent of total meat purchased in frozen form	Shoppers in store number 1	Shoppers in store number 2	Residents in area of store number 2
	Percent	Percent	Percent
0%	18	28	60
1-25	15	26	27
26-50	20	14	5
51-75	6	5	3
76-100	41	27	5
Total	100	100	100

Why Do You Shop Here?

The first question asked the shoppers was: "Do you buy frozen meat because that is all that is available at this market, or do you shop at this market because they sell frozen meat or both?"

In both of the stores, the main factors influencing customers to buy frozen meat were reasons other than the fact that the meat was frozen. Five percent of those interviewed at the No. 1 store bought meat at the market because it was frozen and an additional 32 percent of those interviewed indicated that the fact that it was frozen was an important factor influencing them to buy meat there. In the No. 2 store, freezing seemed to be less important to the customers.

TABLE 5—Reasons given for buying meat at the market

	Frozen meat is all that is sold	Desire frozen meat	Desire frozen meat plus other reasons	Did not buy
	Percent	Percent	Percent	Percent
Store number 1.....	53	5	32	10
Store number 2.....	53	2	19	26

Which Would You Buy?

In an attempt to find out the degree of satisfaction with frozen meat the shoppers were asked, "If this store sold both fresh and frozen meats, which would you then buy?" Answers are given in Table 6.

The question implies that the meat merchandised in the fresh or frozen form would be identical in every respect except for the freezing.

One of the more important findings of the study was that of the 60 percent of the residents of the area surrounding the No. 2 store, who had not purchased any frozen meat from either of the two stores in the 30 days prior to the interview, 78 percent said they would buy meat at the store if both fresh and frozen meat were sold. An additional 4 percent of this group were undecided and only 18 percent of the group said they would continue not shopping for meat at either of the markets.

Many of those interviewed who purchased less than 100 percent of their meat at the stores indicated that they would buy more meat at the store if the markets sold fresh meat in addition to the frozen.

TABLE 6—Percent interviewed who indicated desire to purchase fresh or frozen if both were merchandised at the market

Location	Only fresh	Only frozen	Both	Neither	No reply	Total
	Percent	Percent	Percent	Percent	Percent	Percent
Shoppers in store number 1.....	23	19	57	1	0	100
Shoppers in store number 2.....	54	14	29	2	1	100
Residents in area of store number 2.....	49	5	30	11	5	100

Shoppers who did not buy meat at the markets often said that they wanted at least some of their meat non-frozen, especially to serve immediately after purchasing and if they had to go to a different market to purchase non-frozen meat, they would buy all their meat at that market. Other shoppers who purchased one-half or more of their meat at the store frequently said that they would like to be able to purchase certain cuts in the fresh form or that they often would like to buy fresh meat to prepare immediately. They objected to the defrosting time.

Does Freezing Affect Quality of Meat?

Response to the question, "Do you believe freezing affects the quality of meat?" is given in Table 7.

Of the residents interviewed in the area of the No. 2 store, 95 percent indicated that they freeze at least part of the meat which they buy in non-frozen form. They were then asked if they felt that home freezing affected the quality of the meat. Five percent said it improved quality, 12 percent said it reduced it, 75 percent said it did not affect quality, and 8 percent did not know. A higher percentage of residents interviewed in this area felt that the quality of the meat was decreased by commercial freezing than by home freezing techniques.

TABLE 7—Effects of freezing on quality

	Improves	Decreases	No effect	Do not know
	Percent	Percent	Percent	Percent
Shoppers in number 1 store	16	10	69	5
Shoppers in number 2 store	12	26	60	2
Residents in area of number 2 store	6	18	73	3

Is It More Expensive?

The question was asked, "Do you believe that frozen meat is more or less expensive than fresh meat of comparable quality?" This question is difficult to analyze with any degree of reliability because of the different connotations of comparable quality and the different trimming techniques used for frozen and fresh meats. Nevertheless, the answers should reflect the *beliefs* of the consumers as to the

prices of frozen versus fresh meat in this particular area. Approximately ⅓ of all those interviewed believed that frozen meat was more expensive, ⅓ believed it was less expensive and ⅓ did not know.

WHAT DID THEY LIKE ABOUT THE FROZEN MEAT?

In attempting to determine what consumers liked and disliked about frozen meat, two forms of questions were used. The customers were asked first why they purchased frozen meat from the market. Assuming that customers know at all times why they shop at a particular market for a certain product, this question was intended to obtain the reasons foremost in the customer's mind.

For the second question, customers were shown a card with suggested reasons for buying frozen meat at the market. This question was intended to reveal those reasons which may be either less important to the customer or equally important, but those which the customer had not remembered immediately or had not consciously realized as affecting her decision. The responses to the two questions concerning why customers purchased frozen meat from the market are summarized in Tables 8 and 9.

These responses refer to the meat which the shoppers may purchase in the non-frozen form. They may not apply to the meat which the customers normally purchase in the frozen form. In other words, the shopper may have indicated that she prefers to buy roasts in the fresh form because she can see the size and shape, but she has no objection to not being able to see ground beef or pork chops.

One of the most serious objections to buying frozen meat was the inability to see the meat, so it seemed important to analyze this objection more closely.

TABLE 8—Stated reasons for buying frozen meat at the supermarket

Response	Shoppers in store number 1	Shoppers in store number 2	Residents in area of store number 2
	Percent	Percent	Percent
High, dependable quality of the meat...	74	46	27
Desire frozen meat.....	37	20	1
Convenient to the store.....	9	36	32
Can buy larger supply.....	3	7	0
Other.....	2	2	6

TABLE 9—Response to suggested reasons for buying frozen meat

Reason	Shoppers in store number 1	Shoppers in store number 2	Residents in area of store number 2
	Percent	Percent	Percent
Easy to store the meat (ready for freezer)	65	52	38
Can buy larger supply	45	32	21
Convenient to buy exact size portions and quality desired	32	12	(*a*)
More tender	18	12	4
Fresher	15	12	7
Tastier	12	12	7
Cheaper per pound of edible meat	7	0	4
Other	2	2	13
No reply	18	35	18

(*a*) Statement was not properly presented in these interviews.

In questioning the shoppers further, they were asked, "Do you object to this particular market overwrapping meat so that you cannot see it?" The responses are listed below.

Response	Shoppers in store No. 1 percent	Shoppers in store No. 2 percent
Yes	28	58
No	72	42

A total of 22 percent of all those interviewed in the study did not feel that any of the suggested considerations were important to them.

OBJECTIONS TO FROZEN MEAT

The largest single objection to frozen meat was that consumers could not see the meat. The objection in many cases was not an expression of distrust of the quality or trim of the meat, but rather the lack of ability to look at a package of overwrapped frozen meat and determine if it was the size needed to serve the family. After consumers had used the meat for a period of time, they became accustomed to visualizing the serving size of the various packages. However, the new, or potentially new, customers expressed a serious objection to not being able to see the meat.

Time required to defrost frozen meat was the second most frequently given objection. In many cases, the objection was not seri-

ous. Housewives stated they found defrosting inconvenient when they work away from home or forget to take the package out of the freezer on time.

Many of those interviewed either did not know that most meats can be prepared without prior defrosting or stated that they did not have success preparing frozen meat which was not previously defrosted. The supermarket has displayed information on cooking time and techniques to use in preparing frozen meats, but evidently this had not reached a large number of the shoppers.

The third most prevalent objection to frozen meat was flavor. A number of those interviewed felt that freezing lowers the flavor of certain cuts of meat. Some suggested it made the meat drier, especially if kept frozen for an extended period of time. Others could not describe the change in flavor which had taken place.

The stated objections of those interviewed in the three areas are summarized in Table 10.

TABLE 10—Stated objections to frozen meat(a)

Objection	Shoppers in store number 1	Shoppers in store number 2	Residents in area of store number 2
	Percent	Percent	Percent
Cannot see the meat	20	47	45
Defrosting time	37	25	25
Poor flavor	11	28	13
No storage space	1	2	12
Too expensive	2	16	12
Difficult to prepare	2	0	3
No objection	35	21	37

(a) These are responses to the open end question, "What objections do you have to frozen meat?"

In addition, the shoppers were shown a card on which were listed possible reasons for preferring to purchase non-frozen meat and were asked to indicate if any were important to them. The responses to this question are shown in Table 11.

It is clear that at the No. 1 store, a number of customers have become familiar enough with the product so that they did not feel that they had to see each package of meat. In the No. 2 store, a rather large percentage of those interviewed did object to not being able to see the meat.

Some shoppers said they did not object to the overwrap because

TABLE 11—Responses to suggested reasons for preferring non-frozen meat

Reasons	Shoppers in store number 1	Shoppers in store number 2
	Percent	Percent
Can see the meat	52	60
Can see color of meat	32	27
Do not have to defrost	39	42
Less expensive	14	29
Better flavor	10	29
Better color	5	5
More tender	1	2
Did not check any	26	19

they could open the package to inspect the size of portion, etc. whenever they felt the need to do so. Other customers stated they understood that in order to preserve the quality of the meat properly, it had to be overwrapped and thus, even though they might like to see the meat, they did not object to the overwraping if it did a better job of preserving quality.

The second question directed at analyzing the customer's objections to overwrapping was, "Do you depend on the labeling of meat at this market more than your ability to look at fresh meat and consistently select the quality which you desire?" The responses were as follows:

Response	Shoppers in store No. 1 percent	Shoppers in store No. 2 percent
Yes	56	28
No	43	67
No response	1	5

This shows the differences in attitude of the shoppers at the two stores. It also reflects on the promotion accomplishments at the two stores. Of those who indicated that they did depend on the labeling over their own ability, many were emphatic about this point and stated that they knew very little about meats and were quite anxious to shift the responsibility for selecting quality meats to the market.

Even though merchandisers of fresh meat attempt to convey the thought that they are selecting high quality meat for the customer, the fact that she must look at several packages of meat and

select the one which she wants may infer that the shopper is assuming some responsibility in selecting the quality of the meat.

The third question directed at analyzing the shoppers' attitudes of not being able to see the meat was, "Do you find it more convenient to shop for meat which is overwrapped and labeled as it is at this store?" The responses are listed below.

Response	Shoppers in store No. 1 percent	Shoppers in store No. 2 percent
Yes	39	17
No	45	57
No response	16	26

Again the differences between the two stores are apparent.

CONCLUSIONS

1. The No. 1 store, which evolved from a locker plant, has built up a sizable clientele of customers satisfied with frozen meat largely because it is marketing high quality meat of dependable grade and consistency of trimming.

2. Convenience is the most significant advantage of frozen meat for the customer. The most important convenience aspects are that it is easy to store and the shopper can buy a larger supply.

3. The most serious objection of shoppers to frozen meat is not being able to see the product. This objection can be overcome quite satisfactory by clearly identifying grade, adhering carefully to grade, and trimming consistently.

MICHIGAN FARM BUSINESS REPORT FOR 1960

By CHARLES BEER[1]

DEPARTMENT OF AGRICULTURAL ECONOMICS

THE 1960 EARNINGS for a sample of Michigan farms shows a slight increase over the earnings for 1959. (Table 1). Total investment increased by $5,910 on the average farm, and the return earned on this investment was 0.4 percent greater than that earned in 1959. (Table 3). Eight of the nine areas for which reports are prepared showed an increase in labor earnings above the 1959 figures. Area 6-7 showed a sizable decrease because of an increased investment without a corresponding increase in net cash income. (Tables 4 and 6).

The data presented in this report was obtained from the farm account records of 933 farmers throughout the state, who keep these records as part of the Cooperative Extension Service program in each county. The records were summarized under the supervision of farm management specialists in the Agricultural Economics Department at Michigan State University.

Separate reports, which contain more detailed information, are prepared for individual areas of the state. These are prepared and distributed by the Department of Agricultural Economics.

FARM EARNINGS

The earnings, shown as labor income, are presented in Table 1. These figures cover a 32-year period, the length of time this project has been operating in Michigan. Labor income, as shown here, is the return to the farm operator for his labor and management. It is calculated by deducting from the gross income all cost operating expenses, depreciation, family labor (other than operator), and 5 percent interest on the investment in the farm operation.

[1]Co-workers on this project are J. Doneth, L. Brown, E. Elwood, L. Kyle, M. Kelsey, R. Hartwig and R. Wheeler. Appreciation is also expressed to the county extension agents and to the cooperating farmers for their contribution which provided the data for this article.

ARTICLE 44-32

TABLE 1—Earnings on farm accounting farms in Michigan by years: 1929-1960, and 32-year average

Year	Labor income	Year	Labor income
1929	$ 585	1945	$2,483
1930	−263	1946	3,374
1931	−676	1947	3,486
1932	−595	1948	2,735
1933	249	1949	1,815
1934	565	1950	2,688
1935	764	1951	3,782
1936	1,318	1952	2,926
1937	569	1953	2,447
1938	571	1954	1,755
1939	780	1955	993
1940	787	1956	2,646
1941	1,675	1957	2,360
1942	2,303	1958	3,426
1943	1,900	1959	2,049
1944	2,406	1960	2,339
32-year average, 1929-1960			$1,695

Lest the reader be misled by average figures, Table 2 shows a classification of these farmers into three income groups. In this breakdown, 24 percent of the 933 farmers were in the "red" for 1960. That is, they had a labor earning of zero or less. Eleven percent had labor incomes ranging from $1 to $1,000 and 65 percent had incomes of $1,000 or more.

These figures reveal, in a general way, what is taking place on Michigan farms, but they do not represent the average farmer as shown by the census reports. The farmers keeping accounts in this project generally have larger farms than the average of all Michigan farms. As a group, they are considered better than average operators. All the farmers used a standardized bookkeeping procedure and had their farm business records summarized at the university. The sample of farms changes slightly from year to year. Therefore, the earning figures between various years may not be entirely comparable.

The charge for family labor, the inventory values for feed and crops and for non-breeding livestock are changed each year in an attempt to keep data in line with current conditions. Relatively fixed values are used for land, improvements, and breeding stock. Land values were adjusted upward in 1959 to reflect more closely the cur-

rent market value. The 1960 land investment figures reflect a similar relationship to current market value.

Actually, the decrease in 1959 farm earnings is not as severe as these figures indicate. Only about one-third of the $1,377 decline in labor income was due to a poorer income-expense relationship. Two-thirds of the drop resulted from additional interest charged to investment. The land investment was increased almost 60 percent because of revision of land values.

One other observation is important, but not apparent from these figures. These earning figures represent only the results from farm operation. The figures do not include the increase in value of farm real estate, which in some areas has been considerable.

TABLE 2—Percentage and distribution of labor incomes, 1929-1960

Period	Total number of farms	Farms in each labor income group		
		$0 or less	$1 to $1,000	$1,000 and over
		Percent	Percent	Percent
1929-33, 5-year average..	750	58	33	9
1934-38, 5-year average..	1,050	16	53	31
1939	1,346	14	54	32
1940	1,263	12	55	33
1941	1,041	5	27	68
1942	1,160	2	18	80
1943	1,097	8	24	68
1944	1,031	5	18	77
1945	939	6	17	77
1946	838	4	9	87
1947	830	5	11	84
1948	846	8	15	77
1949	912	9	16	75
1950	826	11	17	72
1951	685	7	9	84
1952	551	13	11	76
1953	501	20	14	66
1954	545	25	18	57
1955	539	34	17	49
1956	526	17	11	72
1957	881	22	12	66
1958	862	15	8	77
1959	887	26	12	62
1960	933	24	11	65

FINANCIAL SUMMARY

Gross income has increased steadily since 1955 to a high of $21,431 in 1960. Expenses have also increased and at a more rapid rate.

Comparing 1960 with 1959, the expenses increased by 16 percent ($2188), while gross income increased by 15 percent ($2774). This resulted in an 11 percent increase in net farm income. The interest charge on investment increased by 8.6 percent, leaving a labor income of 14 percent above 1959.

A different way of showing returns to farmers is to include in costs a charge for operator's labor instead of the charge for interest on investment. After such charge has been made (see bottom of Table 3), the net is shown as a percent of the total investment figure,

TABLE 3—Comparison of gross income, expenses, and labor income on accounting farms in Michigan, 1955-1960

Item	1955	1956	1957	1958	1959	1960
Income:						
Crops	$ 2,521	$ 3,600	$ 2,814	$ 3,956	$ 3,956	$ 4,133
Dairy products	5,476	6,840	8,198	8,247	9,212	10,403
Cattle	1,514	1,745	1,621	2,988	2,921	3,507
Hogs	620	903	1,093	1,320	867	1,533
Poultry and eggs	1,125	868	729	782	708	828
Sheep	100	119	116	102	102	86
Other	737	780	954	888	891	941
Gross income	$12,093	$14,855	$15,525	$18,283	$18,657	$21,431
Expenses:						
Feed	$ 1,655	$ 1,863	$ 1,820	$ 2,209	$ 2,184	$ 2,704
Machinery	2,889	3,201	3,479	3,698	3,959	4,240
Hired labor	886	1,024	850	1,019	1,168	1,322
Family labor	639	672	700	734	885	831
Crop expense	1,490	1,554	1,591	1,971	2,138	2,363
Improvements	768	842	1,028	1,178	1,225	1,381
Taxes	317	391	432	513	566	653
Other	578	639	787	882	986	448
Marketing expense	.....	.....	.....	.....	.....	1,357
Total expenses	$ 9,222	$10,186	$10,687	$12,204	$13,111	$15,299
Net farm income	$ 2,871	$ 4,669	$ 4,838	$ 6,079	$ 5,546	$ 6,132
Interest on investment at 5%	1,878	2,023	2,478	2,653	3,497	3,793
Labor income	$ 993	$ 2,646	$ 2,360	$ 3,426	$ 2,049	$ 2,339
Investment	$37,560	$40,460	$49,560	$53,060	$69,940	$75,850
Net farm income	$ 2,871	$ 4,669	$ 4,838	$ 6,079	$ 5,546	$ 6,132
Operator's labor charge	2,050	2,049	2,070	2,065	2,477	2,492
Return on investment	$ 821	$ 2,620	$ 2,768	$ 4,014	$ 3,069	$ 3,640
Rate earned on investment	2.2%	6.5%	5.6%	7.6%	4.4%	4.8%

TABLE 4—Cash summary for all Michigan accounting farms and for various areas (a) for 1960

Item	All farms	1	2	4	5	6 and 7	8	9-12-14	10	15-16-17
Cash income										
Crop sales	$ 4,004	$ 5,392	$ 3,522	$ 2,336	$ 4,062	$ 2,220	$10,957	$ 1,298	$ 5,063	$ 1,618
Dairy products	10,403	7,809	8,374	11,526	13,642	13,646	6,756	8,317	11,221	7,625
Dairy cattle	1,812	1,570	1,958	1,850	2,180	2,225	1,244	1,593	1,762	1,281
Beef	3,494	13,828	3,178	707	4,049	2,639	4,123	656	946	425
Eggs	860	881	1,309	2,648	608	826	995	641	310	533
Poultry meat	65	34	70	144	45	149	99	42	22	15
Hogs	1,502	2,991	4,327	853	1,869	889	606	268	682	30
Sheep and wool	123	175	254	53	203	34	47	102	60	32
Custom work	227	378	167	162	247	194	423	122	200	135
Labor off farm	235	352	174	278	126	177	232	330	224	410
Machinery cash sales	64	76	102	53	69	26	84	61	75	30
Other sources	490	523	446	429	392	467	532	413	455	836
Total	$23,279	$34,009	$23,881	$21,039	$27,493	$23,492	$26,098	$13,343	$21,020	$12,970
Cash expenses										
Purchased feed	$ 2,704	$ 4,339	$ 3,660	$ 3,609	$ 2,932	$ 2,829	$ 2,006	$ 1,639	$ 1,796	$ 1,480
New machinery bought	2,681	2,912	2,332	2,595	3,354	2,588	3,258	1,839	2,882	1,608
Other machinery expense	2,147	2,666	1,957	1,794	2,405	2,294	2,522	1,523	2,297	1,479
New improvements	1,390	1,267	1,193	2,185	1,959	1,508	1,490	652	1,024	717
Other improvement expense	551	664	519	542	676	571	506	388	547	384
Livestock bought	2,773	8,332	2,679	1,408	3,758	2,196	3,000	506	1,327	382
Milk marketing and other livestock expense	1,357	1,300	1,279	1,403	1,727	1,590	872	1,211	1,306	969
Hired labor	1,322	1,587	1,082	980	1,566	1,390	1,449	755	1,747	981
Crop expense	2,092	3,010	2,205	1,620	2,502	1,961	3,019	957	2,062	915
Custom hire	271	394	295	191	342	240	412	127	210	110
Taxes	653	883	627	578	850	794	758	312	494	254
Other expenses	448	548	417	402	535	463	440	320	424	355
Total	$18,389	$27,902	$18,245	$17,307	$22,606	$18,424	$19,732	$10,229	$16,116	$ 9,634

(a) See Fig. 1.

TABLE 4—Concluded

Item	All farms	1	2	4	5	6 and 7	8	9-12-14	10	15-16-17
Inventory change										
Farm improvements	$ 548	$ 203	$ 442	$ 1,371	$ 940	$ 614	$ 299	$ 177	$ 402	$ 222
Orchard	....	....	....	....	....	....	....	....	....	....
Machinery	524	760	315	665	860	260	600	326	465	182
Feed and crop	129	231	140	693	145	650	94	356	528	140
Hogs	193	357	472	152	178	297	154	48	27	−8
Sheep	−8	−60	−16	−7	8	−7	−2	−4	−17	−3
Poultry	14	−13	63	65	−5	6	56	−1	5	....
Dairy cattle	531	256	223	630	948	448	240	326	962	312
Beef cattle	142	−375	−465	382	712	146	208	−42	26	−12
Net inventory change	$ 2,073	$ 1,359	$ 1,174	$ 3,951	$ 3,786	$ 1,114	$ 1,649	$ 1,186	$ 2,398	$ 833
Summary										
Net cash income	$ 4,890	$ 6,107	$ 5,636	$ 3,732	$ 4,887	$ 5,068	$ 6,366	$ 3,614	$ 4,904	$ 3,336
Inventory increase	2,073	1,359	1,174	3,951	3,786	1,114	1,649	1,186	2,398	833
Net income	6,963	7,466	6,810	7,683	8,673	6,182	8,015	4,800	7,302	4,169
Family labor	831	1,120	655	967	878	852	896	794	699	654
Net farm income	6,132	6,346	6,155	6,716	7,795	5,330	7,119	4,006	6,603	3,515
Interest on investment	3,793	5,002	3,857	3,455	4,421	4,191	4,935	2,413	3,068	1,826
Labor income	$ 2,339	$ 1,344	$ 2,298	$ 3,261	$ 3,374	$ 1,139	$ 2,184	$ 1,593	$ 3,535	$ 1,689

(*a*) See Fig. 1.

thus giving the rate earned on capital invested in the farm business. On these farm account farms, the rate earned on capital investment has averaged about 5 percent over the last several years.

The financial summary on a cash basis is shown in Table 4. Cash income, inventory changes, and an earnings summary are shown for all account farms and also for each of the type-of-farming areas in the state, with the exception of the fruit account cooperators farms.

Physical changes which occurred on these sample farms are shown in Table 5. The increase in acreage, both total and tillable, continues. The amount of livestock and work load are well above the 1955 figures.

TABLE 5—Comparison of size of farm and amount of work on Michigan farm account farms, 1955-1960

Item	1955	1956	1957	1958	1959	1960
Number of farms	539	526	881	862	887	933
Total acres	234	245	259	263	270	285
Tillable acres	167	178	188	194	200	210
Animal unit	38.0	39.7	42.5	54.0	49.0	61.5
Man-work units	411	451	465	546	541	529
Number of men	1.7	1.6	1.6	1.7	1.7	1.8
Work units per man	258	271	290	320	309	300

TYPE-OF-FARMING AREA INFORMATION

The previous figures and information are an average of all account farms throughout the state, exclusive of fruit farms in the 1957, 1958, 1959 and 1960 figures.[2] Tables 6, 7, 8, and 9 present information for the type-of-farming districts in the state. Some areas have been combined so that the data is presented by districts in the state. Some areas have been combined so that the data is presented by districts rather than individual type-of-farm areas. Fig. 1 shows the type of farming areas in Michigan.

The data presented includes a financial summary; the kind of crops grown, crop yields and percent of land in each crop; the kind, amount and return of livestock; and the various expenses and their relationship to each other.

[2]For details on the specialized fruit farms, the author suggests the use of the Area 3-11 report, A. Ec. 810, 1961, published by the department of agricultural economics, Mich. State Univ.

TYPE-OF-FARMING AREAS IN MICHIGAN
(Areas on a natural-line basis)
1. General Livestock and Corn
2. Dairy, Livestock and Corn
3. Southwestern Fruit, Dairy and Truck
4. Dairy, Poultry and Truck
5. Dairy and General Farming
6. Dairy, Part-time and Truck
7. Dairy and Cash Crops
8. Cash Crops and Dairy
9. General Livestock and Part-Time
10. Dairy, Potatoes and Truck
11. Northwestern Fruit and Dairy
12. Dairy, Part-Time and Potatoes
13. Forestry, Part-Time and Cattle
14. Cattle, Potatoes and Part-Time
15. Cattle, Hay and Part-Time
16. Dairy and Potatoes
17. Dairy, Potatoes, Part-Time and Forestry

Fig. 1. Type-of-farming areas in Michigan (Areas on a natural-line basis).

TABLE 6—Financial summary of 933 Michigan account farms by type-of-farming area, 1960

Item	All farms	1	2	4	5	6 and 7	8	9-12-14	10	15-16-17
Number of farms	933	82	106	52	225	115	89	86	74	104
Total acres	285	258	275	208	311	270	250	294	281	336
Percent of farm acres tillable	74	83	80	83	79	81	82	58	71	51
Tillable acres	210	214	221	173	246	218	206	171	199	171
Real estate (less house)(*a*)	$49,712	$65,236	$52,304	$46,684	$57,030	$55,094	$71,793	$31,135	$37,360	$19,813
Machinery and equipment	$ 9,862	$10,356	$ 9,513	$ 8,875	$11,006	$11,039	$11,078	$ 7,343	$10,482	$ 7,149
Livestock(*a*)	$10,486	$16,345	$ 9,838	$ 9,275	$13,106	$11,783	$ 7,760	$ 7,046	$ 8,616	$ 6,537
Feed and crops	$ 5,790	$ 7,938	$ 5,539	$ 4,259	$ 7,269	$ 5,888	$ 8,070	$ 2,733	$ 4,901	$ 3,020
Capital investments (*a*)	$75,850	$99,875	$77,194	$69,093	$88,411	$83,804	$98,701	$48,257	$61,359	$36,519
Livestock income	$16,357	$19,121	$17,067	$17,596	$20,678	$19,103	$11,526	$11,438	$14,678	$ 9,849
Crop income	4,133	5,623	3,663	3,029	4,206	1,570	11,051	1,653	5,591	1,758
Other income	941	1,240	784	801	765	836	1,175	821	872	1,378
Gross income	$21,431	$25,984	$21,514	$21,426	$25,649	$21,509	$23,752	$15,912	$21,141	$12,985
Total expense (*b*)	21,586	27,239	21,825	20,834	24,871	23,003	24,147	14,540	19,825	13,474
Net farm income	$ 6,132	$ 6,346	$ 6,157	$ 6,716	$ 7,795	$ 5,329	$ 7,119	$ 4,006	$ 6,603	$ 3,515
Less interest at 5%	3,793	5,002	3,859	3,455	4,421	4,190	4,935	2,413	3,008	1,826
Labor income 1960	$ 2,339	$ 1,344	$ 2,298	$ 3,261	$ 3,374	$ 1,139	$ 2,184	$ 1,593	$ 3,535	$ 1,689
Labor income 1959	2,049	86	1,258	1,245	2,678	2,705	2,929	1,637	2,456	1,512
Labor income 1958	3,426	5,431	4,730	3,004	4,237	3,166	2,847	1,548	2,672	1,603
Labor income 1957	2,360	2,353	3,433	2,357	2,477	1,927	2,747	1,783	3,008	1,348
Labor income 1956	2,646	2,690	3,380	2,244	3,075	2,938	3,756	2,180	2,089	1,163
Labor income 1955	993	1,420	387	−126	729	1,198	2,752	886	652	841
Labor income 1954	1,755	3,079	1,172	917	2,451	786	2,238	916	918	588
Labor income 1953	2,447	3,283	2,142	1,914	2,999	1,542	3,403	1,296	1,537	916
Labor income 1952	2,926	2,984	2,916	2,930	3,589	3,103	3,742	1,826	2,485	1,797
Labor income 1951	3,782	4,533	4,845	3,752	5,173	3,633	4,726	2,309	3,233	1,888
Labor income, 10-year average	$ 2,472	$ 2,720	$ 2,426	$ 2,150	$ 3,078	$ 2,214	$ 3,132	$ 1,597	$ 2,259	$ 1,335

(*a*) Investment figures tend to represent long time account book and not current valuations.
(*b*) Includes family labor and operator's labor and interest on investment.

TABLE 7—Kinds of crops, percentage of tillable land in different crops, and yields on farm accounting farms: by type-of-farming areas in Michigan, 1960

Item	All farms	1	2	4	5	6 and 7	8	9-12-14	10	15-16-17
Number of farms	933	82	106	52	225	115	89	86	74	104
Number of tillable acres	210	214	221	173	246	218	206	171	199	171
Percent in sod crops	39	22	32	41	33	41	22	62	48	66
Percent tillable acres in:										
Tillable pasture	12	6	12	10	11	13	6	22	14	19
Alfalfa hay	17	11	15	24	19	18	13	17	21	13
Other hay	9	4	4	5	3	9	2	20	11	34
Grass silage	1	1	1	2	..	1	1	3	2	..
Corn (includes silage)	30	49	39	31	38	28	24	14	21	3
Wheat	10	12	12	11	11	9	13	4	7	..
Oats (oat mixtures)	9	9	10	9	7	6	7	10	7	16
Barley	1	..	1	1	..	1	..	1	..	..
Field beans	3	..	..	..	1	..	19	..	3	..
Soybeans	..	7	..	..	..	..	..	..	..	..
Sugar beets	..	..	..	..	..	..	8	..	..	..
Potatoes	..	..	..	..	..	..	..	..	..	2
Fruit and truck	..	1	..	..	..	..	..	..	..	..
Other	3	4	3	3	5	6	3	5	7	5
Idle	5	..	3	4	5	9	4	5	7	8
Crop yield per acre:										
Alfalfa hay, ton	3.1	3.1	3.2	3.3	3.3	3.3	3.0	2.3	2.9	2.5
Other hay, ton	2.2	2.4	2.0	2.4	2.4	2.4	2.7	2.1	2.1	1.9
Corn, shelled, bu	66	76	58	65	67	60	74	52	64	..
Wheat, bu	35	48	35	33	35	30	41	31	31	..
Oats, bu	62	71	67	66	69	60	73	47	53	48
Barley, bu	35	..	38	..	..	30	..	..	..	..
Beans, bu	25	..	..	..	..	..	..	..	30	..
Sugar beets, ton	..	..	..	..	..	..	15.0	..	..	..
Potatoes, bu	..	..	..	..	..	..	..	..	..	403
Soybeans, bu	..	21	15	..	21	..	..	..	..	..
Crop value per tillable acre	$ 53	$ 64	$ 48	$ 54	$ 54	$ 44	$ 23	$ 39	$ 59	$ 42
Crop sales and ASC payments	$4,004	$5,392	$3,522	$2,336	$4,062	$2,220	$10,957	$1,298	$5,063	$1,618
Crop income total	$4,133	$5,623	$3,663	$3,029	$4,206	$1,570	$11,051	$1,653	$5,591	$1,758
Feed bought	$2,704	$4,339	$3,660	$3,609	$2,932	$2,829	$ 2,006	$1,639	$1,796	$1,480
Fertilizer per tillable acre	$ 5.84	$10.15	$ 7.40	$ 6.61	$ 5.45	$ 2.73	$ 9.97	$ 3.28	$ 5.38	$ 2.87

TABLE 8—Livestock: kinds, amounts, and returns from livestock: by type-of-farming areas on farm accounting farms in Michigan, 1960

Item	All farms	1	2	4	5	6 and 7	8	9-12-14	10	15-16-17
Number of farms	933	82	106	52	225	115	89	86	74	104
Livestock income total	$16,357	$19,121	$17,067	$17,596	$20,678	$19,103	$11,526	$11,438	$14,678	$ 9,849
Livestock income per tillable acre(*a*)	77.94	89.35	77.14	101.76	84.03	87.73	55.88	67.68	73.71	57.59
Productive animal units	61.5	77.7	62.7	48.4	66.4	56.4	38.2	42.1	46.2	38.4
Tillable acre per P.A.U. (*b*)	3.4	2.8	3.5	3.6	3.7	3.9	5.4	4.0	4.3	4.5
Cattle:										
Percent farms reporting	76	51	62	88	82	87	54	81	85	89
Dairy cows per farm	31.2	35.1	32.4	29.0	36.5	34.7	26.8	24.0	31.4	25.0
Dairy product sales per cow	$434	$430	$442	$446	$457	$452	$468	$419	$417	$342
Dairy sales on farms reporting	13,593	15,129	13,448	12,937	16,665	15,693	12,519	10,069	13,109	8,527
Income/farms reporting (beef and dairy)	2,323	7,868	10,811	2,519	4,471	3,280	4,028	2,082	2,596	1,527
Hogs:										
Percent farms reporting	32	44	63	37	44	12	25	28	12	6
Sows per farm	13.3	16.5	18.5	6.1	10.2	29.6	9.3	8.6	5.0	4.1
Litters farrowed/farm	22.0	34.8	33.7	11.6	17.8	58.9	15.6	12.2	10.0	5.7
Pigs weaned/litter	7.3	7.3	6.9	8.1	6.8	6.3	7.0	8.3	9.3	9.4
Hog income per litter	$269	$257	$469	$277	$265	$273	$256	$126	$341	$140
Income/farms reporting	4,783	6,788	7,063	2,553	4,190	9,372	2,179	1,012	4,108	398
Sheep:										
Percent farms reporting	9	11	16	4	14	6	3	10	14	4
Ewes per farm	66	44	42	48	42	20	51	61	150	43
Lambs raised/100 ewes	41	76	94	97	100	75	109	85	109	112
Sheep income per ewe	$21	$21	$28	$26	$21	$17	$26	$15	$24	$14
Income/farms reporting	885	932	910	1,220	894	329	1,341	858	3,549	615
Poultry:										
Percent farms reporting	30	33	35	46	26	34	31	34	16	29
Hens/farm reporting	461	485	663	1,117	470	479	586	421	274	262
Egg sales per hen	$5.64	$5.52	$7.22	$6.17	$5.70	$5.98	$5.39	$5.94	$6.95	$7.27
Egg sales/farm reporting	2,601	2,676	4,786	5,737	2,357	2,868	3,164	2,503	1,901	1,906
Meat income per farm reporting	3,773	−249	−121	−142	24	229	−233	−252	45	−85

(*a*) Tillable acre.
(*b*) Productive animal unit.

TABLE 9—Expenses and efficiency factors, labor, machinery, improvements, and other costs on farm accounting farm: by type-of-farming area in Michigan, 1960

Item	All farms	1	2	4	5	6 and 7	8	9-12-14	10	15-16-17
Number of farms	933	82	106	52	225	115	89	86	74	104
Gross income per tillable acre	$102.10	$121.42	$97.24	$123.91	$104.23	$98.78	$115.53	$81.57	$106.17	$75.93
Total expense per tillable acre(*a*)	102.83	127.28	98.64	120.48	101.06	105.64	117.07	85.25	99.56	78.78
Total expenses(*a*)	21,585	27,239	21,825	20,834	24,871	23,003	24,147	14,540	19,824	13,474
Man labor:										
Number of men	1.8	1.9	1.6	1.6	1.8	1.9	1.8	1.6	1.9	1.6
Income per man	$12,139	$13,676	$13,182	$13,046	$14,117	$11,483	$13,214	$8,462	$11,336	$7,929
Days of work per man(*b*)	300	290	306	319	334	315	282	250	282	263
Hired labor	1,322	1,587	1,082	980	1,566	1,390	1,449	755	1,747	981
Family labor	831	1,120	655	967	878	852	896	794	699	654
Operator's labor	2,493	2,599	2,609	2,669	2,596	2,632	2,579	2,221	2,219	2,178
Expense per tillable acre	$22.13	$24.79	$19.64	$26.70	$20.48	$22.38	$23.87	$22.10	$23.43	$22.29
Power and machinery:										
Investments	9,862	10,356	9,513	8,875	11,006	11,039	11,078	7,343	10,482	7,149
Income/$1,000 investment	$1,195	$2,509	$2,261	$2,414	$2,330	$1,948	$2,151	$1,894	$2,017	$1,816
Annual expense	4,240	4,742	3,870	3,672	4,830	4,596	5,096	2,973	4,638	2,876
Expense per tillable acre	20.20	22.16	17.49	21.24	19.63	21.11	24.70	17.43	23.29	16.81
Improvements:										
Investment (less house)	$13,898	$18,345	$12,903	$13,528	$16,255	$14,783	$19,234	$7,270	$10,983	$8,505
Investment per productive animal unit	226	236	206	279	244	262	503	175	238	222
Annual expense	1,381	1,715	1,265	1,289	1,693	1,464	1,685	819	1,161	876
Expense per tillable acre	6.58	8.01	5.72	7.45	6.88	6.72	8.17	4.80	5.83	5.12
Feed bought	$2,704	$4,339	$3,660	$3,609	$2,932	$2,829	$2,006	$1,639	$1,796	$1,480
Crop expense	2,092	3,010	2,206	1,620	2,501	1,961	3,019	956	2,062	915
Custom hire	271	394	295	191	342	240	412	127	210	110
Taxes (real estate)	653	883	627	578	850	794	758	312	494	254
Other expenses	5,598	6,850	5,556	5,259	6,683	6,245	6,247	3,944	4,798	3,150
Feed bought per tillable acre	$12.88	$20.28	$16.54	$20.87	$11.91	$12.99	$9.73	$9.61	$9.02	$8.66
Crop expense/tillable acres (less custom)	9.97	14.06	9.97	9.37	10.16	9.01	14.64	5.61	10.36	5.35
Custom work per tillable acre	1.29	1.84	1.34	1.10	1.39	1.10	2.00	.74	1.05	.64
Real estate taxes at tillable acre	3.11	4.13	2.83	3.35	3.46	3.65	3.68	1.83	2.48	1.49
Other expenses per tillable acre	26.67	32.01	25.11	30.40	27.15	28.68	30.28	23.13	24.10	18.42

(*a*) Includes operator's and family labor, and interest on investment.
(*b*) Fruit farms excluded.

HATCHING POWER OF PATERNAL VS. MATERNAL FIRST COUSINS IN CHICKENS

By EARL W. HENDERSON

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That hatching power of chickens is inherited has been amply demonstrated at this[1] and many other stations.

Since male chickens are known to carry an "extra" sex chromosome in their germ cells it has been speculated that they might possibly have more influence on the transmission of hatching power than their sisters. There is little experimental evidence to support such theory. It is well known that some qualitative, dominant genetic characters, such as Silver are carried exclusively on the sex chromosomes. Such a biological phenomenon is known as sex-linked inheritance. Because of the nature of the mechanics of cell division in chickens the "extra" or sex determining chromosome of the male, comes from his dam.

In a recent statistical analysis of hatching records at M.S.U. there was a slight but insignificant indication that the paternal granddam had more influence on the hatchability of granddaughters than their dams. This finding suggested the possibility of dominant hatchability genes on the "sex" chromosomes. If any such genes for hatchability were located on the "sex" chromosomes, a son would get at least one more of them from a mother than his sisters would. This happens because the mother transmits her lone "sex" chromosome to her sons exclusively, along with half the normal (diploid) quota of non-sex chromosomes or autosomes. The daughters get the other half of the autosomes but no sex chromosome. The sex chromosome that a daughter gets comes from her sire.

As a hypothetical example, assume that gene "H." (for high hatchability) may be located on the sex chromosome of a hen. When such

[1]Henderson, Earl W. (1960). The influence of inheritance on hatching power of 18 generations of chickens. Mich. Agr. Expt. Sta. Quart. Bul. 42: 596-606.

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is the case gene "H." passes to her sons where its influence cannot be evident until the next generation. Theoretically the influence of gene "H." will reappear in the hatching performance of the paternal granddaughters. If gene "H." possessed any degree of dominance, granddaughters (by way of sons) would be better hatchers than those by way of daughters.

Biologists do not know how hatchability genes are distributed among the chromosomes. In fact the total number of chromosomes of chickens is not established to date. Regardless of the exact number of chromosomes carried by chickens, microscopic studies are generally agreed that males have an even number of chromosomes and that females have (n-1) pairs of chromosomes plus a single unpaired chromosome.

Although the number and location of hatchability genes in the chromosomes of chickens is not known as yet, pedigree hatching performance records do not indicate that hatching power is transmitted exclusively, at least, by means of the sex chromosomes.

MATERIALS AND METHODS

In order to test for a "sex linked dominance" hypothesis, pedigree hatchability records for the past 10 years from project No. 266 of the Michigan Agricultural Experiment Station were searched for pairs of maternal and paternal first cousins. There were only forty pairs of such cousins with adequate records of five or more fertile eggs set in the same year. The mean percentage hatch of the two sets of granddaughters (first cousins) was compiled and shown in Table 1.

The differences between the individual hatching records of the two kinds of cousins from the same grandparents were subjected to the analysis of variance statistical technique. Because of unavoid-

TABLE 1—Average hatchability—Percentages of fertile eggs hatched by paternal vs. maternal first cousins

Paternal 1st cousins		Maternal 1st cousins	
Number	Percent hatched	Number	Percent hatched
40.....	85.3	40.....	85.9

able variation in the number of fertile eggs from different hens, the influence of each hen was reduced to unity by means of the "percentage of fertile eggs hatched" index.

RESULTS AND DISCUSSION

The averages of the hatches of each kind of granddaughter (paternal and maternal) are shown in Table 1. The averages of both kinds of granddaughters were so nearly the same (85.3 vs. 85.9) that a statistical computation to determine significance hardly seemed worthwhile. Nevertheless an analysis was made and lack of significance of the difference in hatchability between 40 pairs of first cousins was established.

These results may be taken as a small bit of evidence that hatching power is not sex linked. In other words the dam and sire are of equal importance in the transmission of hatching power.

THE SUNCLING PEACH

By STANLEY JOHNSTON and J. E. MOULTON
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THE MICHIGAN AGRICULTURAL EXPERIMENT STATION announces the introduction of the Suncling peach. This is a clingstone variety recommended only for commercial processing.

The Suncling variety originated from a cross between PI 35201 and N.J. 196 (PI 35201 x N.J. 196), made by the New Jersey Experiment Station in 1951. One hundred seeds of this cross were sent to the South Haven Experiment Station where they were germinated, the seedlings brought into fruiting, and evaluated. Suncling was selected in 1957 and given the selection number SH 382.

Suncling matures about with Ambergem, or 10 to 12 days earlier than Elberta. The tree is vigorous and productive. Fruit buds are unusually hardy and flowers are very resistant to frost.

Fruits of Suncling are medium-large, nearly round and uniform in shape. Skin color is mostly golden, overlaid with some bright red where exposed to the sun. Pubescence is so short and soft that it is almost unnoticeable. Flesh is clear, orange-yellow, fine textured, and very firm. The stone, or pit, is small and clings to the flesh.

Suncling has been repeatedly tested by processors, both for canning and processing as baby food, and has been found satisfactory for these purposes. This variety should be grown *only* for use in commercial processing. It is not a fresh market peach.

HISTORY OF CLINGSTONE PEACHES IN MICHIGAN

Interest in processing clingstone peach varieties began in Michigan in 1921 when the late Wm. E. McEwing, founder of the South Haven Preserving Company, appealed to the South Haven Experiment Station for aid in finding clingstone varieties suitable for canning and which would produce satisfactorily in Michigan.

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Clingstone varieties were brought to South Haven from California, where most of the clingstone peaches are grown in the United States, from other states, and from various parts of the world through the aid of the U. S. Department of Agriculture. California and foreign varieties failed, but a New Jersey Experiment Station selection known as 46 B, obtained in 1923, and tested at South Haven for 14 years, proved to be satisfactory. It was named Ambergem and is now quite extensively grown in Michigan.

While Ambergem has been a very useful clingstone variety, it has serious faults. The tree is susceptible to winter injury. The fruit has a very large pit, and too much red color develops in the pit cavity.

The search has continued for a series of satisfactory clingstone varieties suitable for growing in Michigan, and Suncling is now being released.

Fig. 1. The Suncling peach, a clingstone variety recommended only for commercial processing.

Sources of Nursery Stock

Trees will be available in small numbers from several nurseries in the spring of 1962, and in larger quantities thereafter. The Michigan Agricultural Experiment Station does not have trees for sale.

Prospects for Other Clingstone Varieties

The New Jersey Experiment Station is releasing a series of five clingstone peach varieties. One of these, Babygold 8, (formerly NJC-64), has been tested for several years at South Haven, and can be recommended if a clingstone variety is needed for ripening as late as Elberta season. The other four varieties being released by the New Jersey Experiment Station have just come into production at South Haven, and therefore have not been thoroughly tested in Michigan.

Other new clingstone varieties from the Virginia Experiment Station and the South Haven Station are under trial, and it is believed that a series of clingstone varieties will soon be available for growing in Michigan, producing fruit from about the middle of August until after September 15.

INTENDED AND ACTUAL TRACTOR PURCHASES BY FARMERS IN MICHIGAN, 1959

By K. T. WRIGHT and W. H. VINCENT[1]
Department of Agricultural Economics

INTRODUCTION

In late December 1958, 3-page questionnaires were sent to nearly 1,200 farmers starting Mail-in Accounting records for 1959, asking about their capital investment intentions for 1959. Of these, there were 935 who both returned the questionnaire and completed their accounts for 1959. This report deals only with the tractor information of the questionnaire.

The general objectives of the study were to determine the number intending to make major capital investments in the coming year, the quarter of the year of the intended investment, the amount of the intended investment, and the strength of the intention to make the investment. It was ascertained from the monthly records of expenditure sent in how well intentions were carried out, and such factors as strength of intent and level of net income to actual investments made were related.

This study consisted of three parts: (1) that dealing with tractors, (2) that dealing with other major items of farm equipment, and (3) that concerned with major investments for remodeling or construction of farm buildings.

As part of the questionnaire the farmers were asked to indicate if there was "some chance" of them buying a tractor or "no chance". If there was "some chance" they were asked to indicate the strength of their intention to buy by checking one of the four following categories: (1) "Very certain" — already made or making a deal; (2) "Quite certain" — considerably better than a 50-50 chance; (3) "Fair chance"

[1]This article is a progress report on the tractor section of a study, "Intended and Actual Investments by Farmers," conducted under a Cooperative Agreement between the U. S. Department of Agriculture, Economic Research Service, and the Michigan Agricultural Experiment Station.

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— about 50-50; and (4) "Slight chance" — considerably less than a 50-50 chance. These indications then were analyzed with income and tractor expenditures data from the farmers' regular account project information sheets.

GENERAL FINDINGS

When these 935 farmers were surveyed in late December 1958, some 265, or 28 percent, said that there was "some chance" of them buying a tractor in 1959; 670, or 72 percent said that there was "no chance" of them purchasing (See bottom Table 1). The tabulation of the actual purchases during 1959 showed that 134, or about 50 percent, of those who said there was "some chance" actually purchased tractors. Contrary to their intentions, 91, or 14 percent, of the 670 men who said there was "no chance" of them buying a tractor, actually purchased one. Thus, in the end, a total of 225 men, or 24 percent of the group, actually purchased tractors in 1959.

The farmers were asked not only if they intended to buy a tractor but also how much difference they intended to pay. The 265 men who said there was "some chance" of them buying, said they expected to spend a total of $416,320. The 50 percent of these men actually buying spent $264,389, or some 65 percent of the total intended, and $151,931 less than was intended by the 265 men. The 91 "no chance" men who bought tractors spent $174,877, or $22,946 more than the deficit in the "some chance" group. Thus, total tractor expenditures by all farmers was 6 percent above that intended, due in part to purchases of the men who did not expect to buy.

STRENGTH OF INTENTION TO BUY AND 1959 NET CASH INCOME AS RELATED TO ACTUAL TRACTOR PURCHASES

Strength of Intention

Of the 265 men who in December of 1958 said there was "some chance" of them buying a tractor, 20 were "very certain" they would make the purchase, 43 were "quite certain," 96 said there was a "fair chance," and 106 a "slight chance." (Bottom Table 1.) In other words, 63 or about one-fourth, were either "very certain" or "quite certain," while three-fourths said there was a "fair chance" or "slight chance."

How did actual purchases compare with the intentions? Some 65 percent of the "very certain" men actually purchased tractors, compared with 72 percent for the "quite certain" men, 49 percent

TABLE 1—Farmers' 1959 purchases of tractors, related to the strength of their intentions in December 1958, and their 1959 net cash income (on 935 farms in mail-in accounting project)(a)

Income quartile	Strength of intent to buy a tractor	Average net(a) cash income	Number of farmers:			Total tractor expenditure:		
			Total in group	Actually buying	Percent buying	Intended	Actual	Percent of intended
I. ($10,295 to $36,757)	Very certain...	$20,058	7	5	71	$15,550	$11,478	74
	Quite certain ..	16,582	13	10	77	31,655	32,643	103
	Fair chance ...	16,615	21	10	48	30,723	18,393	60
	Slight chance..	14,810	30	12	40	52,135	24,165	46
	Total or av...	$16,185	71	37	52	$130,063	$ 86,679	$ 67
	No chance.....	13,907	163	39	24	0	81,367	00
	Total or av. .	$14,598	234	73	31	$130,063	$168,046	129
II. ($6,870 to $10,250)	Very certain...	$8,491	3	2	67	$ 9,600	$ 5,900	61
	Quite certain ..	8,664	11	8	73	14,200	11,024	78
	Fair chance....	8,246	28	14	50	38,271	25,677	67
	Slight chance..	8,368	32	15	47	41,707	26,676	64
	Total or av. .	$8,371	74	39	52	$103,778	$ 69,277	67
	No chance.....	8,306	160	22	14	0	42,407	00
	Total or av. .	$8,326	234	61	26	$103,778	$111,684	108
III. ($4,590 to $6,864)	Very certain...	$5,149	5	3	60	$ 5,375	$ 4,515	84
	Quite certain ..	5,543	8	6	75	14,100	13,119	93
	Fair chance....	5,958	21	8	38	32,011	10,715	33
	Slight chance..	5,370	22	7	32	26,650	14,600	55
	Total or av. .	$5,595	56	24	43	$ 78,136	$ 42,949	55
	No chance.....	5,742	178	19	11	0	31,570	00
	Total or av. .	$5,707	234	43	18	$ 78,136	$ 74,519	95
IV. (−$12,407 to $4,586)	Very certain...	$2,059	5	3	60	$ 10,550	$ 9,970	94
	Quite certain ..	2,647	11	7	63	16,600	9,183	55
	Fair chance....	1,587	26	15	58	47,912	35,568	74
	Slight chance..	1,160	22	9	41	29,281	10,763	37
	Total or av. .	$1,659	64	34	53	$104,343	$ 65,484	63
	No chance.....	2,236	169	11	7	0	19,533	00
	Total or av. .	$2,077	233	45	19	$104,343	$ 85,017	81
ALL FARMS	Very certain...	$10,096	20	13	65	$ 41,075	$ 31,863	78
	Quite certain ..	8,938	43	31	72	76,555	65,969	86
	Fair chance....	7,772	96	47	49	148,917	90,353	61
	Slight chance..	8,073	106	43	40	149,773	76,204	52
	Total or av. .	$8,257	265	134	50	$416,320	$264,389	64
	No chance.....	7,456	670	91	14	0	174,877	00
	Total or av. .	$7,683	935	225	24	$416,320	$439,266	106

(a) Income based on net cash income figured as though no purchases of machinery or farm improvements had been made. The group represents all of the 935 farms giving intentions in advance and actual purchases during 1959. The income range was from −$12,407 to $36,757 and averaged $7,683.

for the "fair chance" and 40 percent for the "slight chance." Thus, there was a fair relationship between the strength of the intent to buy and the actual purchase in the following year.

Level of Net Cash Income

The farmers were arrayed on the basis of their net cash income[2] and divided into four equal quarters or quartiles. The high-income quartile had an average net cash income of $14,598 per farm, the second quartile $8,326, the third $5,707 and the low quartile $2,077 (Table 1). Some 31 percent in the high-income quartile said there was "some chance" of them buying a tractor, 32 percent of the second, 23 percent of the third and 27 percent of the last quartile. How did their actual purchases compare with intentions? We find that in the case of the high-income quartile, 52 percent of those intending to buy, actually purchased, 52 percent of the second quartile, 43 percent of the third and a surprising 53 percent in the low-income quartile.

There appeared to be a closer relationship between level of income and actual purchases among the farmers who said there was "no chance" of them buying, than in the "some chance" group. About 24 percent of the men in the "no chance" group in the high-income quarter bought tractors, compared with 14 percent in the second income group, 11 percent in the third and only 7 percent in the low-income group. Thus, in effect the "no chance" men in the upper two income groups were largely responsible for the tractor purchases off-setting those not made by the "some chance" men.

Combining both the "some chance" and the "no chance" tractor purchasers in the four income groups, we find that the high-income quartile spent 129 percent of what they intended on tractors, while the second income group spent 108 percent, the third group 95 percent, and the low-income group 81 percent. Thus, there was a strong relationship between income level in 1959 and actual purchase of tractors that year.

What share of the net cash income was used in the tractor purchase in the above four income groups? The farmers in the high-income quarter actually spent 4.9 percent of their net cash income (as defined earlier) for their tractor purchases, while those in the second income group spent 5.7 percent, the third group 5.5 percent,

[2]Net cash income before any purchases of machinery or expenditures for farm improvements had been deducted.

and the low-income quarter used 17.6 percent of their net cash income for tractor purchases. The average for 935 farmers was 6.1 percent.

Combination of Intent and Income Level

One way of measuring the interrelationship between strength of intent to buy a tractor and income level to actual purchases, would be to compare the number of those intending and actually purchasing in a group composed of the "very certain" and "quite certain" men of income quartiles I and II, with that of the other three quarters of the men in Table 2. About 74 percent of the group just described actually bought the tractors intended. The "very certain" - "quite certain," III - IV income quartiles bought 66 percent of the tractors intended, while the quarter composed of the "fair chance" - "slight chance" and income groups I - II bought 46 percent of the number intended and the quarter composed of the "fair chance" - "slight chance" and income groups II - II, only bought 43 percent of the tractors intended.

Table 3 presents some comparisons of the average amount farmers intended to spend for a tractor and the actual expenditure, grouped according to strength of intent and level of income. The "very certain" men intended to spend $2054 compared with $1413 for the "slight chance" men. The level of income showed less positive relation to intended expenditure. Actual expenditure was generally more than intended, ranging from an average of 19 percent more for the "very certain" men to 26 percent for the "slight chance" men. Farmers in income quartiles I, II and III spent 27 or 28 percent more than intended, while those in group IV spent 18 percent more.

SEASONALITY OF TRACTOR PURCHASES

General Comments

Almost one-half of the 265 farmers at the time of their response to the questionnaire in December 1958 said they expected to buy a tractor in the April through June quarter of 1959, when there was the greatest need (Table 4). The first quarter of the year ranked close to the second in the number of intentions to purchase with a sharp drop-off in the last two quarters of the year.

The number of "some chance" men actually buying in the quarter

TABLE 2—Relationship of strength of intent and income level, to percent tractor purchases of intentions, 1959

INCOME QUARTILE	STRENGTH OF INTENT									
	1. Very certain		2. Quite certain		Percent actual of intended	3. Fair chance		4. Slight chance		Percent actual of intended
	Intending to buy	Actually buying	Intending to buy	Actually buying		Intending to buy	Actually buying	Intending to buy	Actually buying	
	Number of farmers					Number of farmers				
I.	7	5	13	10		21	10	30	12	
II.	3	2	11	8		28	14	32	15	
Total..	10	7	24	18	73.5	49	24	62	27	46.0
III.	5	3	8	6		21	8	22	7	
IV.	5	3	11	7		22	15	26	9	
Total..	10	6	19	13	65.5	43	23	48	16	42.8

TABLE 3—Relationship of strength of intent and income level, to per farm tractor purchases, 1959

INCOME QUARTILE	STRENGTH OF INTENT												Average all "Some chance"		Average "No chance"
	1. Very certain		2. Quite certain		3. Fair chance		4. Slight chance								
	Intended to spend	Actually spent	Intended to spend	Actually spent	Intended to spend	Actually spent	Intended to spend	Actually spent	Intended to spend	Actually spent	Intended to spend	Actually spent	Actually spent
I.	(7) $2,221	(5) $2,296	(13) $2,435	(10) $3,264	(21) $1,463	(10) $1,839	(30) $1,738	(12) $2,014	(71) $1,832	(37) $2,343	(39) $2,086
II.	(3) 3,200	(2) 2,950	(11) 1,291	(8) 1,378	(28) 1,367	(14) 1,975	(32) 1,303	(15) 1,778	(74) 1,402	(39) 1,776	(22) 1,928
III.	(5) 1,075	(3) 1,505	(8) 1,762	(6) 2,186	(21) 1,524	(8) 1,339	(22) 1,211	(7) 2,086	(56) 1,395	(24) 1,790	(19) 1,662
IV.	(5) 2,110	(3) 3,323	(11) 1,514	(7) 1,312	(26) 1,843	(15) 2,371	(22) 1,331	(9) 1,196	(64) 1,630	(34) 1,926	(11) 1,776
Weighted av.	(20) $2,054	(13) $2,449	(43) $1,780	(31) $2,128	(96) $1,551	(47) $1,922	(106) $1,413	(43) $1,772	(265) $1,571	(134) $1,973	(91) $1,922
Percent actual of intended		119		120		124		126		125	

( ) The numbers in parentheses indicate the number of farmers involved.

TABLE 4—Seasonal distribution of farmers' tractor purchase intentions and actual purchases, 935 farms, M.S.U. farm panel, 1959

Quarter of the year	"Some chance" of buying in specified quarter		Intended to buy in another quarter	"No chance" of buying	Total number buying
	Number intending	Number buying	Number buying	Number buying	
Jan.-Mar.	95	30	10	12	52
Apr.-June	115	34	31	37	102
July-Sept.	27	2	11	21	34
Oct.-Dec.	12	3	13	21	37
Total	249(*a*)	69	65	91	225

(*a*) This does not include 16 who did not indicate intended quarter of tractor purchase.

intended followed the same general pattern with 30 percent of the men intending to buy in the second quarter actually purchasing, with 32 percent in the first quarter, but only 7 percent in the third quarter and 25 percent on a very small number in the last quarter. A total of 69 men out of 249 purchased in the quarter that they intended.

There also were 65 "some chance" men who bought tractors in a quarter of the year other than that intended, and one-half of them bought in the second quarter. In addition to these two groups there was the group of 91 men, who said there was "no chance" of buying, who purchased tractors. These men also bought more tractors in the second quarter than any other quarter, like the previous two groups, but they bought proportionately far more in the third and fourth quarters than the other two groups.

When all three groups are combined to get tractor purchases, we find that 102, or about 45 percent of the 225 men buying tractors, purchased them in the second quarter, about 23 percent in the first quarter and about 16 percent in each of the last two quarters.

A comparison of the total quarterly purchases with the intentions shows 52 purchases versus 95 intentions to buy in the first quarter of the year, or about 55 percent. The second quarter's actual purchases were in the order of 90 percent of intentions, while purchases in the third quarter exceeded intentions by about 25 percent, and in the fourth quarter, when intentions were low, actual purchases were about three times as high as the intentions.

Strength of Intent as Related to Time of Purchase

In evaluating the following comments on strength of intent to purchase, one should keep in mind that the term "very certain" meant that the purchase arrangements were already under way; that "quite certain" means considerably better than a 50-50 chance; "fair chance" about 50-50; and a "slight chance" considerably less than 50-50.

Of the 20 men who were "very certain" they were going to buy a tractor, 15 planned to make the purchase in the first quarter of the year, 2 in the second, 1 each in the third and fourth quarters, and 1 did not indicate the quarter (Table 5). Eleven actually purchased in the first quarter and 1 in the second. In the case of the 43 "quite certain" men, 28 intended to buy in the first quarter and 15 in the second. Twelve actually purchased in the first quarter and 6 in the second quarter. Thus, all the purchases by the "very certain" and "quite certain" men were made in the first two quarters of the year.

Of the 96 "fair chance" men, 27 planned to buy in the first quarter, 54 in the second, 11 in the third, 3 in the fourth, and 1 did not indicate quarter. Only 2 actually purchased in the first quarter, 15 in the second, 1 in the third, and none in the fourth. Of the 106 who indicated a "slight chance," 25 planned to buy in the first quarter, 44 in the second, 15 in the third, 8 in the fourth, and 14 did not indicate the quarter. Only 5 actually bought a tractor in the first quarter, 12 in the second, 1 in the third and 3 in the fourth.

Summarizing, only 30 of the 95 "some chance" men intending to buy in the first quarter actually bought tractors then, but 10 who intended to buy in another quarter bought then and 12 more "no chance" men, for a total of 54 purchases in this quarter. In the second quarter, 34 of the 115 intending to buy actually purchased, plus 31 who intended to buy in another quarter and 37 more "no chance" men, for a total of 102. In the third quarter, only 2 of the 27 "some chance" men bought, plus 11 intending to buy in another quarter and 21 "no chance" men, for a total of 34. While in the last quarter of the year, only 3 of the 12 "some chance" men bought, plus 13 intending in another quarter and 21 "no chance" men for a total of 37 tractor purchases. Thus, this year, the percentage of the "some chance" farmers buying in the quarter intended, as indicated in late December of 1958 and January 1959, ranged from 0 to 73 percent (for the "very certain" men in the first quarter) and averaged 26 percent.

TABLE 5—Tractor purchases related to strength of intent to buy and time of purchase, 935 farms, M. S. U. Farm panel, 1959

Quarter of the year	Item	"Some chance" of buying a tractor						"No chance" of buying	Total
		Very certain	Quite certain	Fair chance	Slight chance	Total this quarter	Intended another quarter		
Jan. thru Mar.	Number of farms	15	28	27	25	95	170	670	935
	Farmers making purchase(a)	11	12	2	5	30	10	12	52
	Percent making purchase	73%	43%	7%	20%	32%	6%	2%	6%
April thru June	Number of farms	2	15	54	44	115	150	670	935
	Farmers making purchase(a)	1	6	15	12	34	31	37	102
	Percent making purchase	50%	40%	28%	27%	30%	21%	6%	11%
July thru Sept.	Number of farms	1	0	11	15	27	238	670	935
	Farmers making purchase(a)	0	0	1	1	2	11	21	34
	Percent making purchase	0	0	9%	7%	7%	7%	3%	4%
Oct. thru Dec.	Number of farms	1	0	3	8	12	253	670	935
	Farmers making purchase(a)	0	0	0	3	3	13	21	37
	Percent making purchase	0	0	0	38%	25%	5%	3%	4%

(a) Number making purchase does not check with that in Table 1, as 16 did not indicate quarter of intended purchase.

Income Level as Related to Time of Purchase

The farms were sorted by income level, then the intended tractor purchases by the "some chance" men tabulated each quarter of the year, to see if there was a difference in the seasonal purchase intention pattern (Fig. 1). The number of farmers in each of the 234 farm income quartiles, who said there was "some chance" of them buying a tractor in each quarter of the year, showed roughly the same seasonal pattern. However, the intentions to buy in the first two quarters of the year were some higher in the top income quartiles.

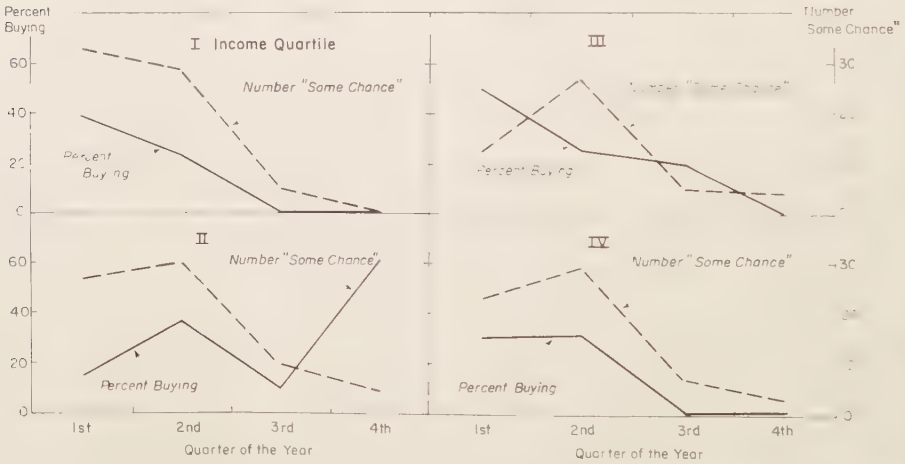

Fig. 1. Relationship of 1959 income quartile to percent actually buying a tractor in the quarter intended, by season of the year, 1959.

The percentage of the "some chance" men who actually purchased in the quarter intended was relatively higher in the first two quarters of the year in all income groups, with little apparent difference among the groups, except the second-income group carried through on intentions much better in the fourth quarter of the year than any other group.

Strength of Intent and Income Level as Related to Time of Purchase

An attempt was made to relate both the strength of intent and income level to time of actual purchase (Table 6). As a general entire-year statement, 60 percent of the "very certain" men purchased when they intended, 42 percent of the "quite certain," 19 percent of the "fair chance" and 20 percent of the "slight chance." Also, as an over-

TABLE 6—Relationship of strength of intent and income level, to percent actually buying a tractor that intended to, by season of year, 1959

Income quartile	Strength of intent of buying a tractor																								
	Very certain					Quite certain					Fair chance					Slight chance					Total				
	Quarter of year					Quarter of year					Quarter of year					Quarter of year					Quarter of year				
	1st	2nd	3rd	4th	Total	1st	2nd	3rd	4th	Total	1st	2nd	3rd	4th	Total	1st	2nd	3rd	4th	Total	1st	2nd	3rd	4th	Total
	Number intending to buy(*a*)																								
I	7	0	0	0	7	8	5	0	0	13	10	9	2	0	21	8	15	3	0	26	33	29	5	0	67
II	3	0	0	0	3	9	2	0	0	11	7	14	5	1	27	8	14	5	4	31	27	30	10	5	72
III	2	2	0	1	5	5	3	0	0	8	3	15	2	1	21	2	7	3	2	14	12	27	5	4	48
IV	3	0	1	0	4	6	5	0	0	11	7	16	2	1	26	7	8	4	2	21	23	29	7	3	62
Total	15	2	1	1	19	28	15	0	0	43	27	54	11	3	95	29	29	15	8	92	95	115	27	12	249
	Percent buying in quarter intended																								
I	57	0	0	0	57	62	20	0	0	46	10	33	0	0	19	38	20	0	0	20	39	24	0	0	28
II	67	0	0	0	67	22	100	0	0	36	0	36	20	0	21	0	28	0	75	21	15	37	10	60	26
III	100	50	0	0	60	60	67	0	0	62	0	13	0	0	9	50	28	33	0	18	50	26	20	0	25
IV	100	0	0	0	60	33	20	0	0	27	14	31	0	0	23	14	38	0	0	18	30	31	0	0	25
Total	73	50	0	0	60	43	40	0	0	42	7	28	9	0	19	20	27	7	38	20	32	30	7	25	26

(*a*) Numbers do not check with those in Table 1, as 16 did not report quarter of intended purchase.

all statement, 28 percent of the high-income quartile men bought when they intended, 26 percent of the second-income group, 25 percent of the third, and 25 percent of the fourth-income group.

One might hypothesize that a higher percentage of the men with both a strong intent to purchase and a high income would be quite likely to purchase when intended, and that those with a weak intention and low income would be less likely to buy as intended. The data presented in Table 6 gives some support to this, but not as much as might be expected. The "very certain" men in the two top income groups carried through with intentions better than the "quite certain," and they better than those with weaker intentions. However, the two lower income groups in most "intention groups" did about as well on their intentions as the two upper income groups.

Strength of Intent and Income Level as Related to Amount Spent

The intended expenditure for tractors and actual expenditure by strength of intent, income level and quarter of the year, are presented in Table 7. Figure 2 shows the dollars spent each quarter by the "very certain" and all the other "some chance" groups in an accumulative fashion, along with the amount spent by the "no chance" men, to get the total amount spent each quarter of the year. All the **"some chance"** groups showed a farily consistent pattern of relatively high expenditure in the first and second quarters, dropping very sharply to a small amount in the third and fourth quarters. The "some chance" men who bought in a quarter of the year other than that intended followed the same general pattern except that their second quarter purchases were much larger than in the first. The **"no chance"** men spent considerably more in the second quarter than any other, so that the total expenditures in the second quarter were $196,000 or 45 percent of the $439,000 annual outlay, with 24 percent in the first quarter, 13 percent in the third quarter and 18 percent in the fourth quarter.

A comparison of actual with intended tractor expenditures by seasons of the year, shows that in the **first** quarter actual purchases fell short of intentions by about 33 percent, or some $52,000, largely because farmers in the II income quartile did not buy as intended (see Table 7 and Fig. 3). In the **second** quarter, purchases exceeded intentions by 15 percent, or $25,000, because farmers in the II income quartile made more purchases than intended. In the **third** quarter, tractor purchases intentions totaled $44,000 on these farms, but actual

TABLE 7—Relationship of strength of intent and income level, to amount intended and actually spent for tractors, by season of year, 1959

Quarter of the year	Income quartile	"Some chance" of buying a tractor										Intended another quarter	"No chance" of buying
		Very certain		Quite certain		Fair chance		Slight chance		Total this quarter			
		Amount intended	Amount spent	Amount intended	Amount spent	Amount intended	Amount spent	Amount intended	Amount spent	Amount intended	Amount spent	Amount spent	Amount spent
Jan. thru March	I.	$15,550	$ 8,044	$17,255	$16,928	$12,980	$ 2,172	$14,512	$ 6,232	$60,297	$33,376	$ 9,590	$ 6,978
	II.	9,600	5,900	13,300	1,800	9,371	0	8,457	0	40,728	7,740	1,414	668
	III.	2,000	4,290	8,600	7,163	6,750	0	2,300	2,291	19,650	13,744	760	7,035
	IV.	8,250	9,970	9,400	2,250	12,460	805	6,125	181	36,235	13,206	9,928	400
	Total	$35,400	$28,204	$48,555	$28,181	$41,561	$ 2,977	$31,394	$ 8,704	$156,910	$68,066	$21,692	$15,081
April thru June	I.	0	0	$14,400	$ 1,775	$13,543	$ 7,568	$25,823	$ 4,304	$53,766	$13,646	$19,008	$31,576
	II.	0	0	900	881	18,600	9,662	16,100	8,214	35,600	18,757	22,716	22,682
	III.	$ 2,000	225	5,500	3,256	19,661	4,550	7,900	8,635	35,061	16,670	4,225	8,832
	IV.	0	0	7,200	1,115	27,052	11,335	12,000	3,235	46,252	15,685	12,412	9,633
	Total	$ 2,000	$ 225	$28,000	$ 7,027	$78,856	$33,115	$61,823	$24,391	$170,679	$64,758	$58,361	$72,623
July thru Sept.	I.	0	0	0	0	$ 4,200	0	$ 5,800	0	$10,000	0	$ 5,182	$19,567
	II.	0	0	0	0	8,700	1,800	8,750	0	17,450	1,800	2,850	11,247
	III.	0	0	0	0	1,600	0	1,500	350	3,100	350	4,500	3,453
	IV.	$ 500	0	0	0	5,900	0	7,133	0	13,553	0	3,553	7,300
	Total	$ 500	0	0	0	$20,400	$ 1,800	$23,183	$ 350	$44,103	$ 2,150	$16,085	$41,567
Oct. thru Dec.	I.	0	0	0	0	0	0	0	0	0	0	$ 5,877	$23,246
	II.	0	0	0	0	$ 1,000	0	$ 6,400	$ 4,700	$ 7,400	$ 4,700	9,300	7,810
	III.	$ 1,375	0	0	0	4,000	0	2,950	0	8,325	0	2,700	12,250
	IV.	0	0	0	0	2,500	0	2,682	0	5,182	0	10,700	2,200
	Total	$ 1,375	0	0	0	$ 7,500	0	$12,032	$ 4,700	$20,907	$ 4,700	$28,577	$45,506

purchases came to about $60,000, or 36 percent more than intended. This was due largely to purchases by farmers in income quartile I, who had said there was "no chance" of their buying a tractor. In the **fourth** quarter, tractor purchase intentions totaled only $21,000 on there farms, but actual purchases totaled nearly $79,000, or almost four times intentions. This again was due to the "no chance" men making purchases, particularly those in the higher income groups.

Thus, actual expenditures for new tractors in the different quarters of the year varied considerably from those intended, because some of the "some chance" purchasers did not buy in the quarter intended, and because quite a few of the "no chance" men changed their minds and bought, especially those in the two top income quartiles. A study of Fig. 3 showing intended and actual tractor purchases by income quartiles of the farmers, shows that actual purchases were close

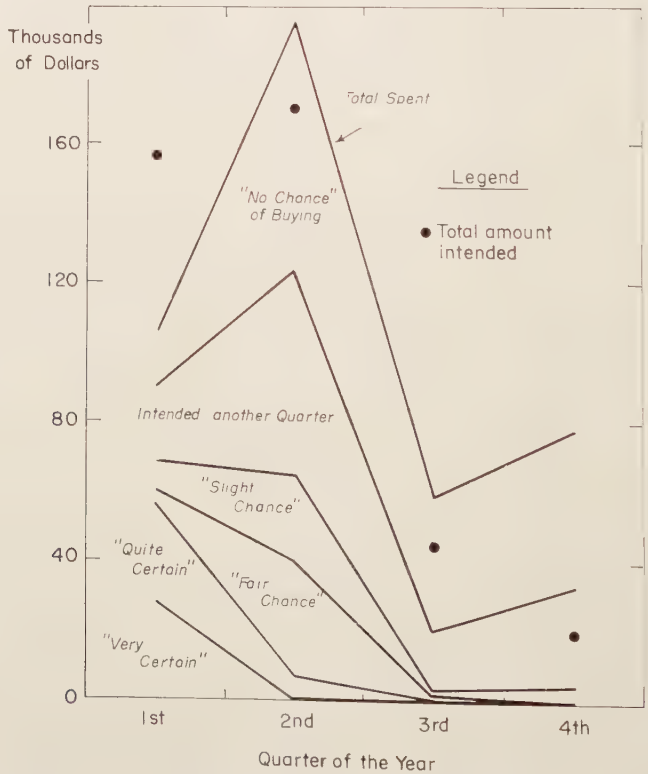

Fig. 2. Relationship of strength of intent to amount intended and actually spent for tractors, by season of the year, 1959.

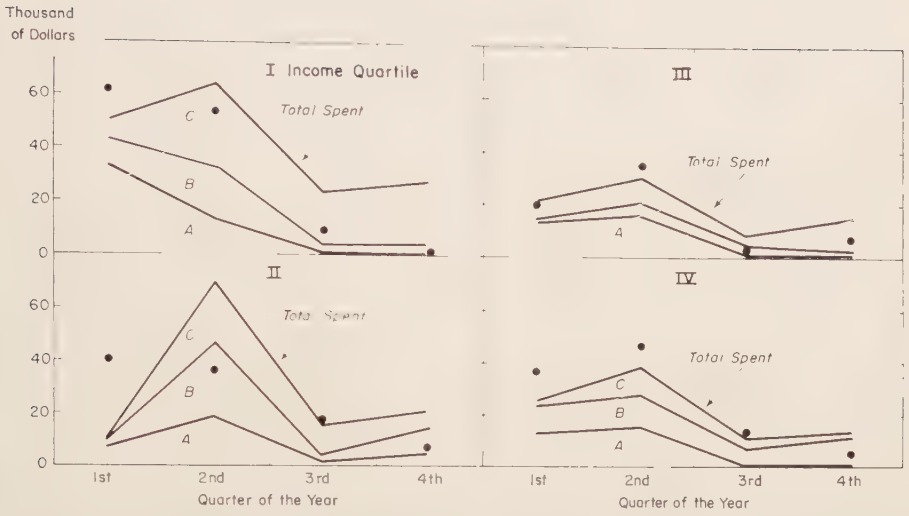

Fig. 3. Relationship of 1959 income level and strength of intent to amount intended and actually spent for tractors, by season of year, 1959.

Legend —

A — "Some chance" men, tractor purchases in quarter intended.
B — "Some chance" men, purchases this quarter intended in another.
C — Purchases by "No chance" men.
• Total intended expenditures.

to intentions each quarter of the year for the two low income quartiles. The divergence of actual from intended purchases, was caused largely by the actions of farmers in the upper income one-half.

1958 INCOME LEVEL AS RELATED TO 1959 INCOME LEVEL, STRENGTH OF INTENT AND TRACTOR PURCHASES

Comparison of 1958 and 1959 Net Cash Incomes

One might think that there would be as good or perhaps a better relationship between the net cash income of farmers in the year previous to their tractor purchases than in the year of the purchases, especially since almost one-half the tractor purchases in the year were purchased in the April-June quarter, before farmers know much about their current net income. Thus, the 1958 net cash income of the men in this study was tabulated and related to their 1959 tractor purchases.

The farmers in the top-income quartile in 1958 had an average net cash income[3] of $13,804, compared with $14,598 for the top quartile in 1959 (Table 8). The men in the second-income quartile in 1958 had an average net income of $7,953 that year, compared with $8,326 for the second group in 1959. Comparable figures for the third-income groups were $5,323 and $5,707 respectively, while those for the low-income groups were $1,975 and $2,077, respectively. The average net cash income for all farms was $7,270 for 1958 and $7,683 for 1959.

Comparison of 1958 and 1959 Income Quartiles as Related to Intentions and Purchases of Tractors in 1959

In this comparison we intend to bring out the comparative relationship of the 1958 and 1959 income level to the percentage of the farmers buying that intended to (Table 8). In the case of the high-income quartiles, 58 percent of the "some chance" men in this group in 1958 bought tractors that intended to, while only 52 percent of the comparable group in 1959 actually bought. In the case of the second-income quartiles, the situation was reversed with a somewhat higher percentage of the 1959 group buying than was true of the 1958 group. There was practically no difference between the third-income quartiles, as 42 and 43 percent of the "some chance" men actually purchased tractors. In the lowest-income quartiles, a higher percentage of the 1958 group carried through with their intentions than was true in 1959 group.

Table 8 also shows the percentage of the "no chance" men in each quartile both years that purchased tractors. There was no significant difference in the percentages purchasing between the two years. However, as was brought out previously in the discussion of 1959 data, there were considerably more "no chance" men that purchased when they were in the top income quartile than was true when they were in the lower income groups.

What about the strength of intent and the percentage actually buying in the four income quartiles in each of the two years? This is shown graphically in Fig. 4. While there were differences in the percentages of those intending to buy that actually purchased, when sorted by net income in 1958 and 1959, the differences between the

[3]Net cash income before any purchases of machinery or expenditures for farm improvements had been deducted.

TABLE 8—Comparison of level of income in 1958 with that in 1959 (by strength of intent) as factors related to farmers' purchases of tractors in 1959

Income quartile 1958	Strength of intent	Sorted by 1958 income quartiles				Sorted by 1959 income quartiles			
		Average net cash income 1958	Number of farmers		Percent buying	Average net cash income 1959	Number of farmers		Percent buying
			Intended to buy	Actually buying			Intended to buy	Actually buying	
I. ($9,488-$38,256)	Very certain.....	$14,792	5	3	60	$20,058	7	5	71
	Quite certain.....	14,345	12	10	83	16,582	13	10	77
	Fair chance.....	14,384	24	13	54	16,615	21	10	48
	Slight chance....	14,250	30	15	50	14,810	30	12	40
	Total or average .	$14,350	71	41	58	$16,185	71	37	52
	No chance.....	13,566	162	36	22	13,907	163	39	24
	Total or average .	$13,804	233	77	33	$14,598	234	73	31
II. ($6,546-$9,471)	Very certain.....	$ 8,491	6	3	50	$ 8,491	3	2	67
	Quite certain.....	8,050	11	6	55	8,664	11	8	73
	Fair chance.....	7,959	26	13	50	8,246	28	14	50
	Slight chance....	7,721	24	8	33	8,368	32	15	47
	Total or average .	$ 7,937	67	30	46	$ 8,371	74	39	52
	No chance.....	7,960	166	23	14	8,306	160	22	14
	Total or average .	$ 7,953	233	53	23	$ 8,226	224	61	26
III. ($4,203-$6,516)	Very certain.....	$ 5,504	4	3	75	$ 5,149	5	3	60
	Quite certain.....	5,306	9	6	67	5,543	8	6	75
	Fair chance.....	5,285	30	12	40	5,958	21	8	38
	Slight chance....	5,205	26	8	31	5,370	22	7	32
	Total or average .	$ 5,270	69	29	42	$ 5,595	56	24	43
	No chance.....	5,345	164	20	12	5,742	178	19	11
	Total or average .	$ 5,323	233	49	21	$ 5,707	234	43	18

TABLE 8—Concluded

Income quartile 1958	Strength of intent	Sorted by 1958 income quartiles				Sorted by 1959 income quartiles			
		Average net cash income 1958	Number of farmers		Percent buying	Average net cash income 1959	Number of farmers		Percent buying
			Intended to buy	Actually buying			Intended to buy	Actually buying	
IV. (−$22,350-$4,203)	Very certain.....	$ 1,471	5	4	80	$ 2,059	5	3	60
	Quite certain.....	1,187	11	9	82	2,647	11	7	63
	Fair chance.....	1,535	16	9	56	1,587	26	15	58
	Slight chance....	2,262	25	11	44	1,160	22	9	41
	Total or average .	$ 1,781	57	33	58	$ 1,659	64	34	53
	No chance.....	2,038	175	13	7	2,236	169	11	7
	Total or average .	$ 1,975	232	46	20	$ 2,077	235	45	19
All	Very certain.....	$ 7,714	20	13	65	$10,096	20	13	65
	Quite certain.....	7,477	43	31	72	8,938	43	31	72
	Fair chance.....	7,659	96	47	49	7,732	96	47	49
	Slight chance....	7,664	105	42	40	8,073	106	43	40
	Total or average .	.....	264	133	50	$ 8,257	265	134	50
	No chance.....	7,125	667	92	14	7,456	670	91	14
	Total or average .	$ 7,270	931	225	24	$ 7,683	935	225	24

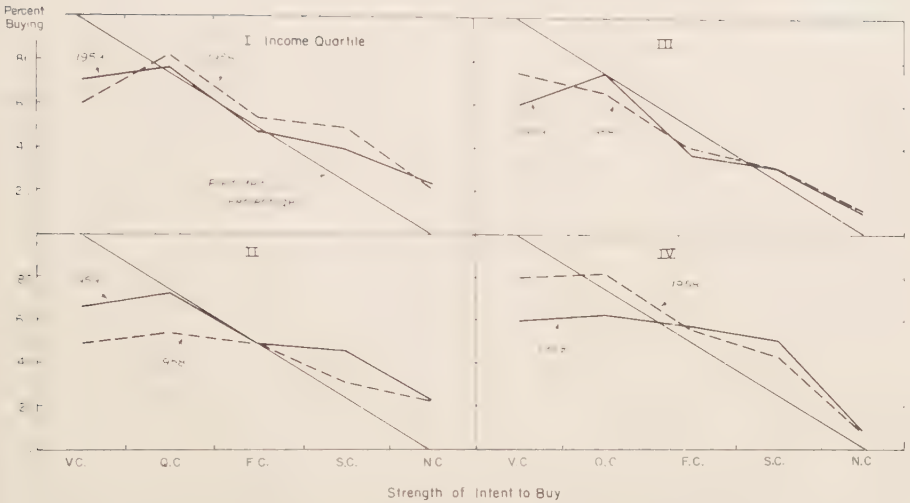

Fig. 4. Comparison of level of income in 1958 and 1959, by strength of intent, as factors related to farmers' purchases of tractors in 1959.

Legend –

V.C. – very certain
Q.C. – quite certain
F.C. – fair chance
S.C. – slight chance
N.C. – no chance

two years do not appear to be significant. In other words, the level of net income in 1958 was as closely related as the level in 1959 to tractor purchases in 1959.

If we arbitrarily estimated that 100 percent of the "very certain" men would buy in the coming year, 75 percent of the "quite certain" men, 50 percent of the "fair chance" men, 25 percent of the "slight chance" men and 0 percent for the "no chance" men, as a predicted percentage relationship line, it could serve as a basis for comparison with the actual. Disregarding the income groups and thinking of the entire 935 farms, only 65 percent of the "very certain" actually purchased, or some 35 percent below the predicted line, while 72 percent of the "quite certain" men purchased putting them 3 percent below the predicted line, and 49 percent of the "fair chance" men (1 percent below). On the other hand, 40 percent of the "slight chance" men purchased, which is 15 percent over the prediction, and 14 percent of the "no chance" men bought, where the prediction was 0 percent. Which goes to show that there is "many a slip between the cup

and the lip" and that more information is needed than "strength of intent to buy" at the end of December and the "income level" in the previous or current year, to have a very high "batting average" in predicting the percentage of farmers who will buy tractors.

Intended Tractor Expenditures and Actual Expenditures by 1958 and 1959 Income Groups

In Table 9 the total amount of money that the "some chance" men intended to spend and actually spent is compared, sorted first by the 1958 income and then by the 1959 income. Also, shown is the amount spent by the "no chance" men in each income quartiles both years.

TABLE 9—Comparison of level of income in 1958 with that in 1959 as related in farmers' intentions and actual purchases of tractors in 1959

Income quartile	Strength of intent	1958 income quartiles			1959 income quartiles		
		Tractor purchases		Percent of intended	Tractor purchases		Percent of intended
		Intended to spend	Actually spent		Intended to spend	Actually spent	
I.	"Some chance"	$131,563	$ 96,718	74	$130,063	$ 86,679	67
	"No chance"	0	76,251	00	0	81,367	00
	Total....	$131,563	$172,969	131	$130,063	$168,046	129
II.	"Some chance"	$105,031	$ 49,079	47	$103,778	$ 69,277	67
	"No chance"	0	40,429	00	0	42,407	00
	Total....	$105,031	$ 89,508	85	$103,778	$111,684	108
III.	"Some chance"	$ 84,434	$ 46,489	55	$ 78,136	$ 42,949	55
	"No chance"	0	34,552	00	0	31,570	00
	Total....	$ 84,434	$ 81,041	96	$ 78,136	$ 74,519	95
IV.	"Some chance"	$ 93,599	$ 70,454	75	$104,343	$ 65,484	63
	"No chance"	0	25,445	00	0	19,533	00
	Total....	$ 93,599	$ 95,899	102	$104,343	$ 85,017	81

There appears to be no significant difference between the amount the "some chance" men *intended* to spend for tractors in 1959 whether sorted by the 1958 income quartiles or by the 1959, except possibly in the third and fourth quartiles. *Actual* expenditures, however, did vary between the two income sorts. For instance, men in the 1958 high-income quartile spent 74 percent of that intended while those in the 1959 high-group spent 67 percent, and those in the second income quartiles spent 47 percent and 67 percent of intentions, respectively. The percentages in the third-income group was the same in both

years. The 1958 low-income group spent 75 percent of what they intended compared with 63 percent for the 1959 low group.

The "*no chance*" men of the high-income group in 1959 spent about 7 percent more than the same 1958 group while the second-income "no-chance" men spent 5 percent more in 1959, while those in the third income quartile spent 9 percent less and the "no chance" men in the bottom group spent 23 percent less in 1959 than in 1958 (Table 9).

Seasonality of Intention and Purchase of Tractors by 1958 and 1959 Income Groups

The relationship of the 1958 level of income to the seasonality of the *intentions* to purchase tractors and actual purchases in 1959, was studied to see if this was any different than the 1959 relationship. As in the 1959 level of income analysis a far larger number in all income quartiles intended to purchase tractors in the first two quarters of the year than in the last two.

The number of farmers in the *1958 high income* quartile indicating "*some chance*" to purchase was about the same each quarter of the year as in the 1959 group (see Figs. 5 and 1). The intentions to purchase by the *second* income group in 1958 was slightly less each quarter than by the 1959 group, while the opposite was true in the *third* income group. The number intending to purchase in the *lowest* 1958 income group was slightly less than in the 1959 low-income

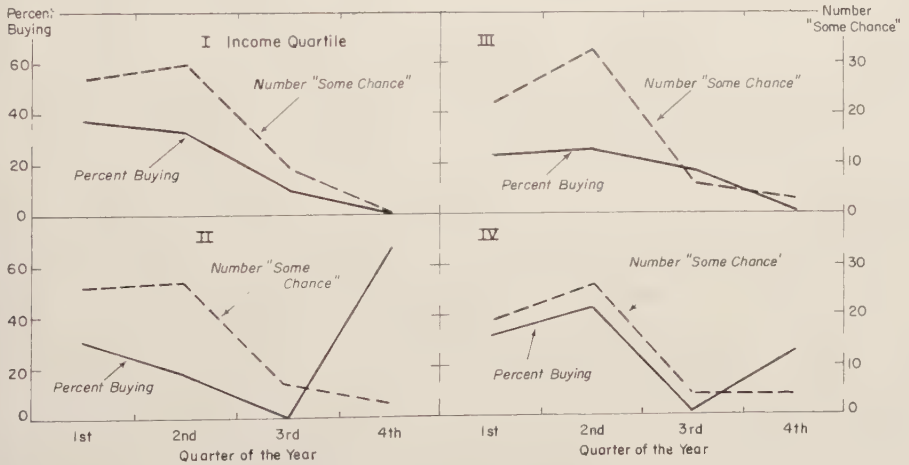

Fig. 5. Relationship of 1958 income quartile to percent actually buying a tractor in the quarter intended, by season of the year, 1959.

group. All in all, there appears to be no significant difference in the seasonal pattern of intentions to purchase tractors, whether based on 1958 income quartiles or 1959 quartiles.

The percentage of those in each income group intending to buy that *actually purchased* in the quarter intended also is shown in Fig. 5. Generally speaking, a higher percentage of those intending to buy in the first two quarters of the year actually purchased in all income groups than in the last half of the year. A comparison of the percentages of those purchasing in the quarter intended, sorted by the 1958 income quartile, with the farms sorted by 1959 income, shows about the same seasoned pattern in both cases.

The actual *tractor expenditures* by the "*some chance*" *men* in the quarter intended and in other quarters, and the "no chance" men as well, by 1958 income quartiles in the four quarters of the year are shown in Table 10 and Fig. 6. Tractor purchases by the "some chance" men of the 1958 high income quartile were high in the first two quarters of 1959, dropping sharply in the last two. Purchases by the "some chance" men in the other three income quartiles also were higher in the first two quarters, but there was less variation than in the top-income group. It should be noted that purchases of tractors by the "some chance" men in quarters other than when intended frequently were of considerable magnitude, and in total was only 10 percent less than purchases in quarters intended.

Purchase of tractors by the "*no chance*" men in the top income quartile were quite high in the second quarter, boosting the total expenditures by all men in that group to $87,000, or over 20 percent of the total annual tractor purchases by all men (Table 10). Purchases by the "no chance" men were a significant share of total purchases in the second-income quartile in the last quarter of the year; in the second quarter of the year in the third income group; and in the third quarter in the low income group. Total tractor purchases by *all men* were greatest in the second quarter, at $196,000, or 45 percent of the total, 24 percent in the first quarter, 13 in the third, and 18 percent in the fourth quarter.

Figure 6 also shows the total intended expenditure for tractor purchases. Total tractor purchases in the 1958 high-income quartile exceeded intentions every quarter, except the first, and particularly in the second quarter, due to the purchases by the "no chance" men. Purchases by those in the 1958 second-income quartile were less than intentions every quarter, except in the last quarter, when "no chance"

of tractors by season of the year in 1959

Income quartile	Quarter of the year	Sorted by 1958 income quartiles: "Some chance" men — Total this quarter: Amount intended	Sorted by 1958 income quartiles: "Some chance" men — Total this quarter: Amount spent	Sorted by 1958 income quartiles: "Some chance" men: Intended another quarter	Sorted by 1958 income quartiles: "No chance" men: Amount spent	Sorted by 1958 income quartiles: Total amount spent	Sorted by 1959 income quartiles(a): "Some chance" men — Total this quarter: Amount intended	Sorted by 1959 income quartiles(a): "Some chance" men — Total this quarter: Amount spent	Sorted by 1959 income quartiles(a): "Some chance" men: Intended another quarter	Sorted by 1959 income quartiles(a): "No chance" men: Amount spent	Sorted by 1959 income quartiles(a): Total amount spent
I.	January-March	$ 52,019	$ 29,287	$ 11,004	$ 5,383	$ 45,674	$ 60,297	$ 33,376	$ 9,590	$ 6,978	$ 49,944
	April-June	52,270	19,810	21,758	45,443	87,011	53,766	13,646	19,008	31,576	64,230
	July-September	20,933	1,800	5,182	19,217	26,199	10,000	0	5,182	19,567	24,749
	October-December	1,341	0	7,877	6,208	14,085	0	0	5,877	23,246	29,123
	Total	$131,563	$ 50,897	$ 45,821	$ 76,251	$172,969	$130,063	$ 47,022	$ 39,657	$ 81,367	$168,046
II.	January-March	$ 45,388	$ 14,996	$ 3,060	$ 668	$ 18,724	$ 40,728	$ 7,740	$ 1,414	$ 668	$ 9,822
	April-June	32,743	9,075	10,598	8,145	27,818	35,600	18,757	22,716	22,682	64,155
	July-September	12,500	0	2,350	7,645	9,995	17,450	1,800	2,850	11,247	15,897
	October-December	7,600	3,000	6,000	23,971	32,971	7,400	4,700	9,300	7,810	21,810
	Total	$105,031	$ 27,071	$ 22,008	$ 40,429	$ 89,508	$103,778	$ 32,997	$ 36,280	$ 42,407	$111,684
III.	January-March	$ 27,000	$ 9,003	$ 1,778	$ 3,435	$ 14,216	$ 19,650	$ 13,744	$ 760	$ 7,035	$ 21,539
	April-June	38,652	14,227	10,278	16,835	41,340	35,061	16,670	4,225	8,832	29,727
	July-September	6,400	350	4,253	4,780	9,383	3,100	350	4,500	3,453	8,303
	October-December	6,041	0	6,600	9,502	16,102	8,325	0	2,700	12,250	14,950
	Total	$ 84,434	$ 23,580	$ 22,909	$ 34,552	$ 81,041	$ 78,136	$ 30,764	$ 12,185	$ 31,570	$ 74,519
IV.	January-March	$ 31,830	$ 14,131	$ 5,850	$ 5,595	$ 25,576	$ 36,235	$ 13,206	$ 9,928	$ 400	$ 23,534
	April-June	46,811	21,646	15,727	4,100	41,473	46,252	15,685	12,412	9,633	37,730
	July-September	4,433	0	3,300	9,925	13,225	13,533	0	3,553	7,300	10,853
	October-December	5,925	1,700	8,100	5,825	15,625	5,182	0	10,700	2,200	12,900
	Total	$ 93,599	$ 37,477	$ 32,977	$ 25,445	$ 95,899	$104,343	$ 28,891	$ 36,593	$ 19,533	$ 85,017
Quarterly totals(b)	January-March	$156,237	$ 67,417	$ 21,692	$ 15,081	$104,190	$156,910	$ 68,066	$ 21,692	$ 15,081	$104,839
	April-June	170,476	64,758	58,361	74,523	197,642	170,629	64,758	58,361	72,623	195,842
	July-September	44,266	2,150	15,085	41,567	58,802	44,083	2,150	16,085	41,567	59,802
	October-December	20,907	4,700	28,577	45,506	78,783	20,907	4,700	28,577	45,506	78,783
	Total	$415,627	$139,025	$123,715	$176,627	$439,417	$416,320	$139,674	$124,715	$174,877	$439,266
Percent of total			31.6	28.2	40.2	100.0		31.7	28.3	39.8	100.0

(a) 935 farms in 1959 sort vs. 931 in 1958.
(b) These do not total in all cases as 16 did not give quarter intended.

men purchased extensively. In the third and fourth income quartiles, total tractor purchases by both the "some chance" men and the "no chance" men were reasonably close to total intentions each quarter.

Figure 6 presents comparable data for 1958 as Fig. 3 which has the farms sorted on the basis of the 1959 income. A comparison of the seasonal pattern of tractor expenditures, shows that there was not much difference between that of the 1958 high-income quartile and the 1959 high-group. Actual tractor expenditures in the 1958 second-income quartile did not show anything like the sharp peak in the second quarter as shown by the 1959 second-income group, and the annual total was about 20 percent less. The seasonal distribution of the total actual tractor purchases and intentions in the third and fourth 1958 and 1959 income quartiles were fairly similar.

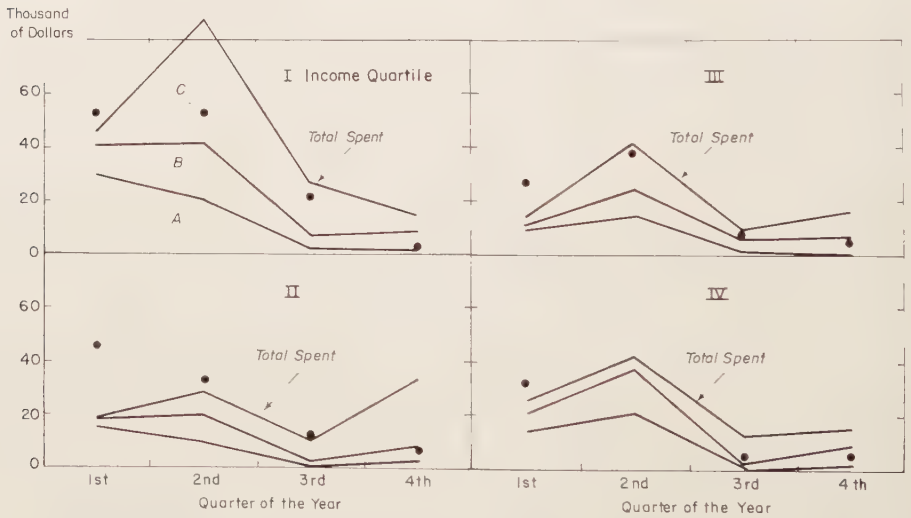

Fig. 6. Relationship of 1958 income level and strength of intent, to amount intended and actually spent for tractors, by season of year in 1959.

Legend —

A — "Some chance" men, tractor purchases in quarter intended.
B — "Some chance" men, purchases this quarter intended in another.
C — Purchases by "No chance" men.

• Total intended expenditures.

Total tractor purchases by all men in 1959 was about $440,000. About 32 percent of this was spent by the "some chance" men in the quarter they intended, 28 percent by "some chance" men in a quarter other than when intended, and 40 percent by the men who had said

there was "no chance" of them buying a tractor in 1959 (Table 10). Or to put it another way, the "some chance" men spent roughly 60 percent of what they intended, with about one-half of that expenditure in the quarter indicated and one-half in some other quarter. Thus, the quarter of the intended tractor purchase, as indicated by these 935 men in December 1958, of the number of tractors and amount of intended expenditure for them, was only a fair indicator of actual expenditures each quarter.

SUMMARY

1. Of the 935 farmers replying to the questionnaire in late December 1958, some 265, or 28 percent said there was "some chance" of them buying a tractor in 1959, while 670, or 72 percent, said there was "no chance."

2. Actual purchases were made by 134, or 50 percent, of the "some chance" men, and 91, or 14 percent, of the "no chance" men, for 225 tractor purchases.

3. Expenditures for tractors by the 50 percent "some chance" men, amounted to 65 percent of the total intended, as they paid more than expected. Tractor purchases by the "no chance" men exceeded the deficit of the "some chance" men, so that total expenditures exceeded intentions by 6 percent.

4. Of the 265 "some chance" farmers, 20 said they were "very certain" they would purchase a tractor, 43 were "quite certain," 96 said there was a "fair chance," and 106 a "slight chance." The percentage actually purchasing was as follows: 65 percent of the "very certain," 72 percent of the "quite certain," 49 percent of the "fair chance," and 40 percent of the "slight chance."

5. When sorted in 1959 net income quartiles, 31 percent of the high-income quartile men indicated "some chance" of purchasing, 32 percent of the second, 23 percent of the third, and 27 percent of the low-group. As to percentage of those actually purchasing, 52 percent of the high-income quartile purchased, 52 percent of the second group, 43 percent of the third, and 53 percent of the low-income quartile. Of the "no chance" men, 24 percent of the top-income quartile purchased tractors, 14 percent of the second group, 11 percent of the third, and 7 percent of the low-income group.

6. Combined purchases by both the "some chance" and the "no chance" men in the high-income group was 129 percent of that in-

tended, 108 percent in the second group, 95 percent in the third, and 81 percent in the low-income group.

7. Twenty-four percent of the 225 tractors purchased were bought in the first quarter, 45 percent in the second, 13 percent in the third, and 18 in the fourth.

8. Total outlay for tractors by all men was 33 percent less than intended in the first quarter of the year, 15 percent above in the second, 36 percent above in the third, and almost four times as much as the small amount intended in the fourth quarter.

9. There was little difference in the percentages of the various "strength of intent" groups actually buying tractors that intended to, whether sorted by 1959 or 1958 income.

MICHIGAN'S ARTIFICIAL PONDS[1]

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Department of Resource Development

INTRODUCTION

Ponds have become important in Michigan as a source of water for agriculture and for various recreational purposes. The number of ponds in Michigan and their use have been of interest for several years, but no comprehensive study was available. This report is a summary of the dominant use and management characteristics for artificial ponds. The map presentation on page 362 shows the distribution of known artificial ponds in Michigan.

Ponds are valuable for uses related to farming and recreational benefits. Occasionally, increased property value has been cited as a reason for their construction. Frequent discussions involving their multiple use have also been used to generate enthusiasm.

Michigan has a well established reputation as "The Water Wonderland" and investigations of artificial ponds would appear to be contradictory to the fact. But air travel over the state provided enough evidence of their importance to justify a more intensive study.

Ponds represent an area or volume of water that is *used* more intensively and completely than most of the natural surface waters of the state. Capital investments, representing construction and maintenance costs, are quite significant. Perhaps more effort should be considered to guide or assist future pond owners.

Most surface water in southern Michigan has already been dedicated to various private and public uses. The construction of ponds can provide surface water for those people who cannot obtain frontage on lakes and streams in the local area of their need or choice.

[1]The authors desire to express their appreciation for suggestions and recommendations received from the following personnel: N. F. Billings, Chief, Hydrology Division, Water Resources Commission; F. E. Carroll, Administrative Office, Agricultural Stabilization Committee; A. B. Cook, Chief, Fish Division, Department of Conservation; R. G. Hill, Resource Development, M. S. U.; E. H. Kidder, Agricultural Engineering, M. S. U.; H. Lakin, Soil Conservation Service.
[2]Former Graduate Research Assistant, Department of Resource Development.

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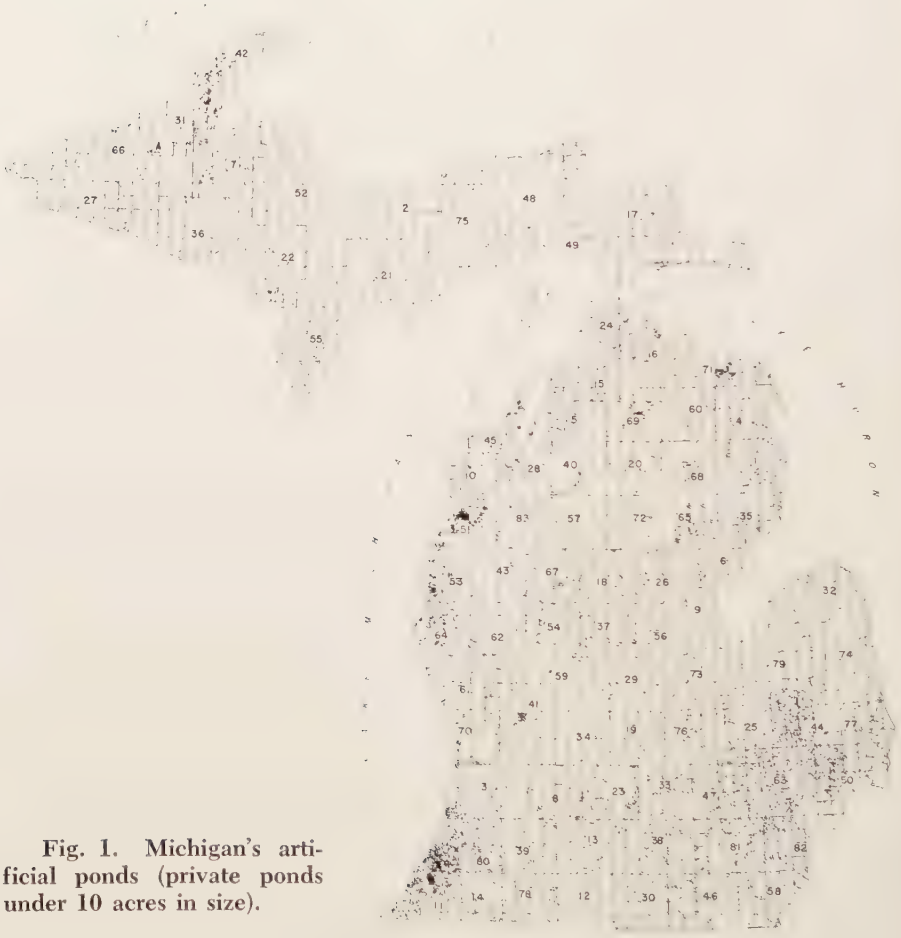

Fig. 1. Michigan's artificial ponds (private ponds under 10 acres in size).

County legend	Total artificial ponds under 10 acres	Estimated total acreage of all known ponds	County legend	Total artificial ponds under 10 acres	Estimated total acreage of all known ponds
1. Alcona	39	33.696	11. Berrien	371	244.328
2. Alger	6	9.200	12. Branch	3	0.750
3. Allegan	118	45.340	13. Calhoun	40	57.750
4. Alpena	19	11.260	14. Cass	59	65.180
5. Antrim	35	12.070	15. Charlevoix	19	4.161
6. Arenac	20	28.105	16. Cheboygan	30	3.190
7. Baraga	46	22.760	17. Chippewa	15	19.650
8. Barry	62	46.784	18. Clare	22	28.578
9. Bay	4	2.700	19. Clinton	17	22.493
10. Benzie	15	3.985	20. Crawford	19	6.400

County legend	Total artificial ponds under 10 acres	Estimated total acreage of all known ponds	County legend	Total artificial ponds under 10 acres	Estimated total acreage of all known ponds
21. Delta	8	1.550	53. Mason	79	17.120
22. Dickinson	27	14.580	54. Mecosta	54	20.880
23. Eaton	65	40.540	55. Menominee	16	3.070
24. Emmet	18	2.960	56. Midland	3	7.830
25. Genesee	45	75.784	57. Missaukee	0	0.000
26. Gladwin	27	35.710	58. Monroe	12	34.909
27. Gogebic	4	0.260	59. Montcolm	39	46.962
28. Grand Traverse	44	15.870	60. Montmorency	8	4.180
29. Gratiot	18	40.860	61. Muskegon	25	3.490
30. Hillsdale	27	25.764	62. Newaygo	59	24.300
31. Houghton	116	72.575	63. Oakland	162	220.188
32. Huron	7	18.500	64. Oceana	79	14.305
33. Ingham	53	49.157	65. Ogemaw	51	45.850
34. Ionia	7	23.690	66. Ontonagon	36	29.100
35. Iosco	20	29.510	67. Osceola	65	97.000
36. Iron	6	11.400	68. Oscoda	21	11.000
37. Isabella	36	28.900	69. Otsego	36	10.620
38. Jackson	65	79.131	70. Ottawa	56	19.488
39. Kalamazoo	62	53.082	71. Presque Isle	41	13.210
40. Kalkaska	20	2.440	72. Roscommon	2	0.200
41. Kent	77	78.021	73. Saginaw	19	26.473
42. Keweenaw	6	1.750	74. Sanilac	24	17.928
43. Lake	12	1.730	75. Schoolcraft	8	13.250
44. Lapeer	175	164.139	76. Shiawassee	38	81.540
45. Leelanau	59	10.940	77. St. Clair	44	27.863
46. Lenawee	32	48.970	78. St. Joseph	56	20.705
47. Livingston	91	109.616	79. Tuscola	14	14.250
48. Luce	3	6.200	80. Van Buren	233	171.465
49. Mackinac	9	24.200	81. Washtenaw	115	148.235
50. Macomb	73	52.662	82. Wayne	51	65.484
51. Manistee	128	57.700	83. Wexford	38	34.922
52. Marquette	10	2.200			

State Totals

1. Total artificial ponds (under 10 acres) in Michigan	3,793	
2. Total ponds of known size	3,362	
3. Total acreage of ponds of known size	2,756.90	acres
4. Average size of artificial ponds in Michigan	0.82	acres
5. Total acreage of all artificial ponds in Michigan	3,094.50	acres

POND SURVEY PROCEDURE

Several agencies in Michigan have been involved with pond construction and use. Each agency has a special interest and their records were not complete for all ponds present in the entire state.

Partial lists were first obtained from the Fish Division, Michigan Department of Conservation and the Water Resources Commission. These lists were combined and reproduced as preliminary county pond survey sheets. Copies of these sheets were forwarded to each of the county Agricultural Stabilization and Conservation Committee office managers with a request that they check their records and add all other ponds known to them (name and address of the owner, location and size).

Every manager provided information available from his files and a second series of preliminary county survey sheets were compiled and reproduced. These were then forwarded to the Soil Conservation Service Area Conservationists and to all of the Fish Division District offices in Michigan. After these reports were received, the final list of ponds was compiled.

State Summary of Pond Survey

Total number of known private artificial ponds in Michigan	*3793*
Total acreage of known private artificial ponds in Michigan	*3094.5*[3]
Average size of artificial ponds in Michigan	*0.82 acres*
Average unit cost of private artificial ponds in Michigan	*$406*[4]

POND QUESTIONNAIRE SURVEY PROCEDURE

The survey provided rather comprehensive data on the number, location and size of Michigan ponds, but several significant questions relating to the source of water supply, use, success and assistance used remained unanswered. A questionnaire was drafted and sent to a random 12 percent sample of pond owners (470 questionnaires mailed). Replies were received from 290 owners, providing a 7.6 percent sample for analysis and interpretation.

Some adjustment was necessary to eliminate those returns which indicated that the reported ponds no longer existed or had been abandoned. After this adjustment there remained 278 valid ponds which were used as the basic sample in analyzing the returns (final sample equivalent to 7.3%).

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[3]Computed by counties:

$$\frac{\text{total acreage of ponds of known size}}{\text{total number of ponds of known size}} \times \text{total number of ponds in the county}$$

[4]Based upon Agricultural Conservation Program records covering 896 ponds.

ANALYSIS AND INTERPRETATION OF THE POND QUESTIONNAIRES

Yearly Pattern of Pond Construction

Thirty-two of the 278 respondents failed to report the year when their pond was constructed (Fig. 2). It is interesting to note that slightly more than 5 percent of the ponds were constructed before 1950; 17 percent were completed during the following 6-year period; and more than 66 percent of *the ponds* were constructed during the period 1955-1961, with peak construction occurring in 1958.

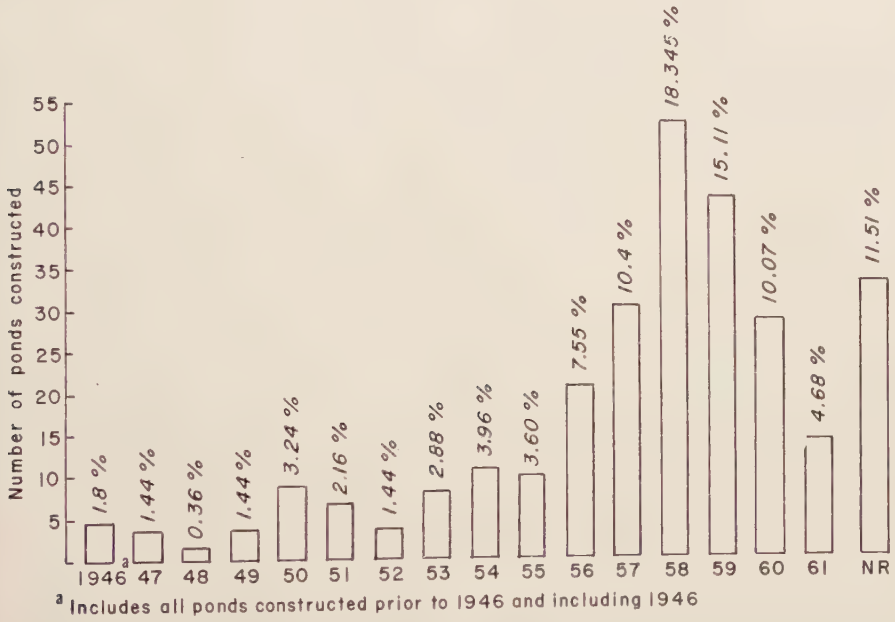

Fig. 2. Yearly pattern of pond construction. Total analyzed—278 questionnaire replies. NR—No response to this part of the questionnaire.

Reasons for the sudden increase in pond construction during the peak period are highly speculative. The Michigan Water Resources Commission, in its survey of "Water Use for Irrigation", reported —2.76 and —0.87 inches departures from normal rainfall during the growing seasons of 1954 and 1955. This dry period could have created an awareness among farm operators of the need to provide supplemental water for irrigation and livestock uses. Also, the Agricultural Conservation Program practice of furnishing financial assistance

TABLE 1—Estimated yearly pattern of artificial pond construction for Michigan, based upon questionnaire data(a)

Year	Number of ponds constructed	Year	Number of Ponds constructed
1946(b)	68	1954	150
1947	55	1955	133
1948	14	1956	286
1949	55	1957	394
1950	123	1958	696
1951	82	1959	574
1952	55	1960	382
1953	109	1961	177

(a) Questionnaire percent × total number of artificial ponds in Michigan.
(b) Includes all ponds constructed prior to and including 1946.

played an important role in the development of ponds, and increasing demands for water by recreationists and other user groups doubtless played a dominant role. This is especially true for the respondents who indicated that they received no help or services from regular channels of assistance.

Sources of Water Supply for Ponds

Response to the question about water supply was quite variable (Fig. 3). Many pond owners indicated that the water supply came from more than one source. More than 53 percent reported springs

TABLE 2—Estimated source of water for Michigan ponds, based upon questionnaire data(a)

Source of water	Number of artificial ponds using source
Spring	2,002
Surface water	1,120
Pothole that has been cleaned out	930
Pit—not next to a stream or lake	930
Pit—near a stream	425
Dam—on a stream	394
Dam—on an intermittent stream	189
Pumped from a well	185
Pit next to a lake	27
Pumped from a lake	27

(a) Questionnaire percent × total number of artificial ponds in Michigan.

as the principal source of water supply; 29.5 percent indicated surface runoff; 24.5 percent reported that natural potholes, which had been cleaned out, contributed water to their ponds; and the same amount of owners said that pits not next to streams or lakes furnished some water.

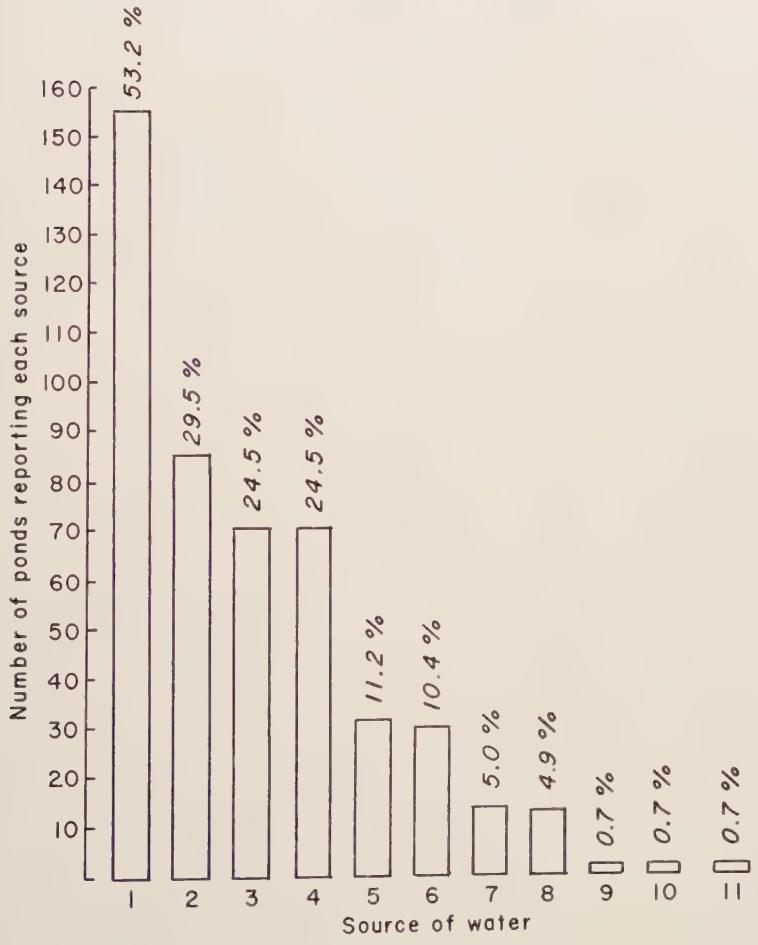

Fig. 3. Water sources for ponds. Legend: (1) spring, (2) surface runoff, (3) pothole that has been cleaned out, (4) pit—not next to stream or lake, (5) pit-near stream, (6) dam on stream, (7) dam on intermittent stream, (8) pumped from well, (9) pit next to lake, (10) pumped from lake, (11) no reply. Note—the percent shown is related to the total number of ponds analyzed—278 replies, and 276 owners checked a total of 457 items under this question.

Bottom Seal

Seepage losses are not an important factor in pond management in Michigan except in areas where ponds are constructed at higher elevations and underlain by a porous substratum. Only 4.6 percent reported lined ponds and these used clay material obtained locally (95.4 percent did not use bottom seal).

There is a definite correlation between ponds used for irrigation and lined ponds. Eleven (approximately 85 percent) of the 13 respondents who lined ponds used them for irrigation purposes. Except for these cases, lining ponds would accomplish little if any benefit. This is especially true where the source of water supply is dependent upon spring flow, ground water, and flowing streams. It is estimated that 174 Michigan ponds are sealed and 3543 ponds are not sealed (questionnaire % X total number of artificial ponds in Michigan).

Uses of Ponds

An analysis of the use of ponds reflects several significant points of interest. A simple frequency study shows that only 16 percent of the respondents used their ponds for a single purpose. The other 84 percent reported two or more uses (Fig. 4).

When all uses were considered, fishing outranked all others. Relative frequency of other uses in order are as follows: improve wildlife habitat, irrigation, fire protection, aesthetic value, swimming, stockwater, spraywater, picnicking, boating, other (including ice skating, increase real value of property), domestic drinking water, and processing water (Fig. 5).

TABLE 3—Estimated pond use frequency analysis for Michigan artificial ponds, based upon questionnaire data(a)

Number of ponds used for one use	601
Number of ponds used for two uses	601
Number of ponds used for three uses	690
Number of ponds used for four uses	595
Number of ponds used for five uses	540
Number of ponds used for six uses	375
Number of ponds used for seven uses	181
Number of ponds used for eight uses	153
Number of ponds used for nine uses	42

(a) Questionnaire percent × total number of artificial ponds in Michigan.

TABLE 4—Estimated uses of Michigan artificial ponds, based upon questionnaire data(a)

Pond uses	Number of ponds
Fishing	2,218
Improve wildlife habitat	1,842
Irrigation	1,810
Fire protection	1,620
Aesthetic values	1,500
Swimming	1,268
Stockwater	1,254
Spray water	928
Picnicking	808
Boating	641
Drinking water	83
Washing and processing water	11
Other	189

(a) Questionnaire percent × total number of artificial ponds in Michigan.

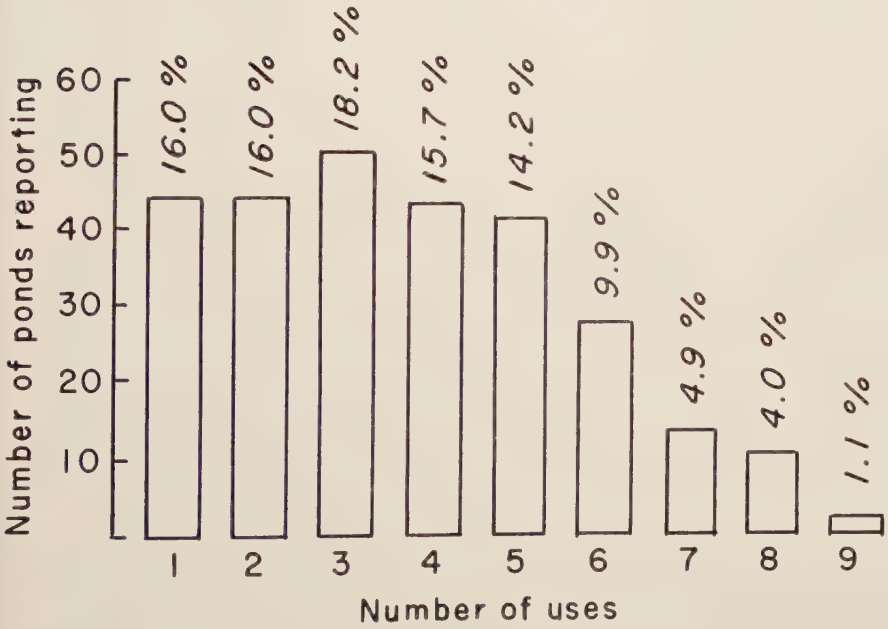

Fig. 4. Pond use frequency analysis. Legend: (1) single use, (2) two uses, (3) three uses, (4) four uses, (5) five uses, (6) six uses, (7) seven uses, (8) eight uses, (9) nine uses. Note: Only 16 percent of the ponds have a single use, and 84 percent are multiple use ponds.

There is a wide variation in the uses of ponds in Michigan and the current trend for additional uses is well underway in keeping pace with the growing importance of water.

Does the Pond Go Dry at any Time?

Only two respondents indicated that their ponds went dry. Perhaps it might be significant to point out that neither of these indicated that outside help was solicited in the design and construction of their ponds.

Sources of Assistance in Design and Construction

An analysis of data relative to outside help in the design and construction of ponds presents other significant facts. Seventy-three

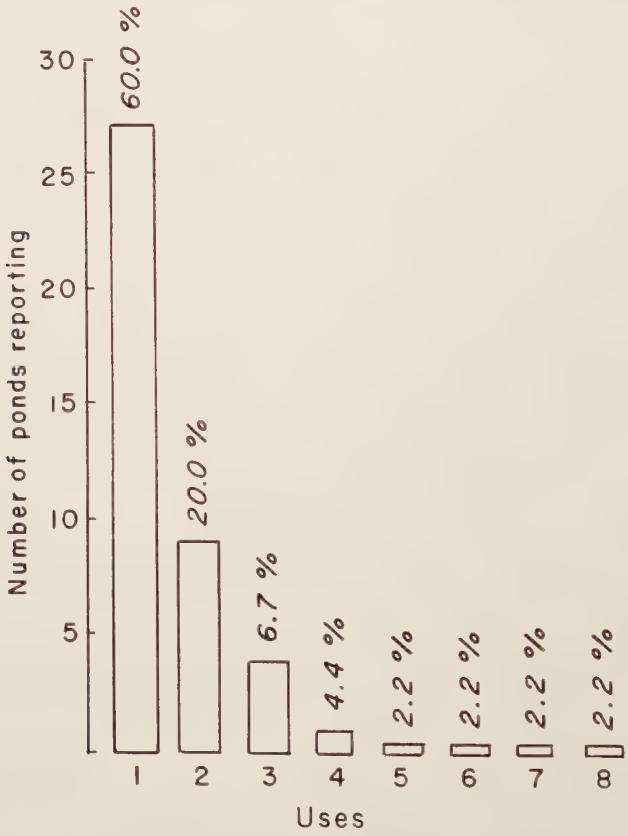

Fig. 5. Graphic analysis of 46 single purpose ponds. Legend: (1) irrigation, (2) stockwater, (3) fishing, (4) aesthetic values, (5) wildlife habitat, (6) spray water, (7) fire protection, (8) increase real estate value.

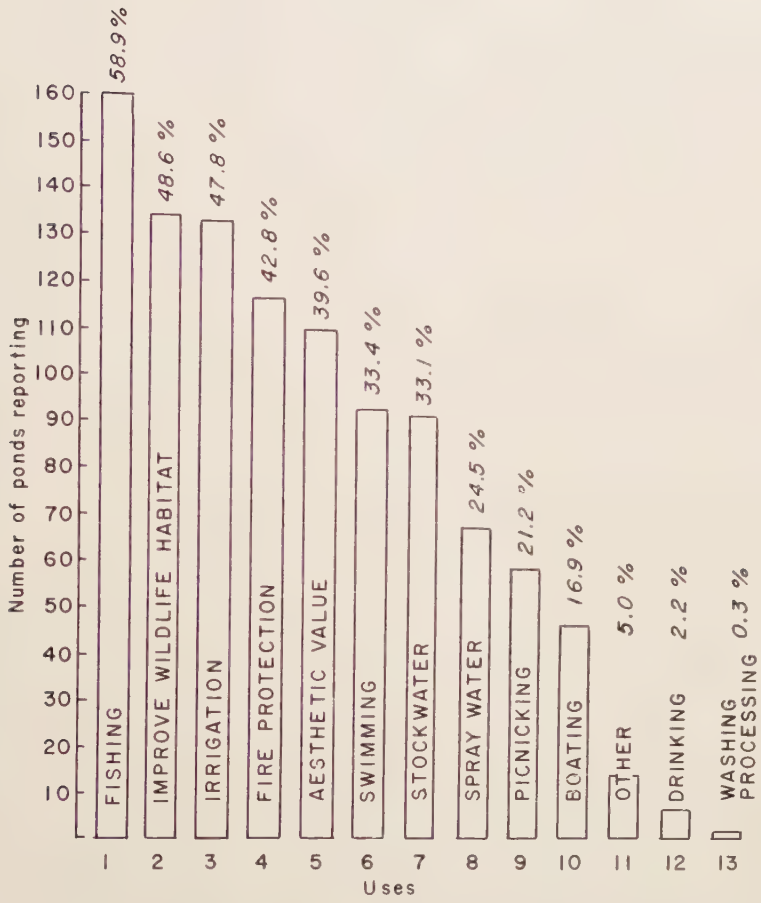

Fig. 6. Uses of ponds. Note: the 278 pond owners checked a total of 1,038 items under this question, and 160, or 58.9 percent of the 278, indicated that their ponds were used for fishing.

percent of those receiving assistance (202) reported help from one or more sources. Some 27 percent (76) failed to respond to the question or else indicated that no assistance was obtained from any source. It is also noted that 17 respondents retained the services of a private engineer, and 10 of them reported this as the only source of assistance. These 10, when added to the group who received no assistance and not reporting, comprise some 30 percent of owners not using regular sources of assistance available to the public.

Collectively, when all sources of assistance were considered, the respondents indicated that the Soil Conservation Service was called

upon most frequently; followed closely by the Agricultural Conservation Program (Fig. 7).

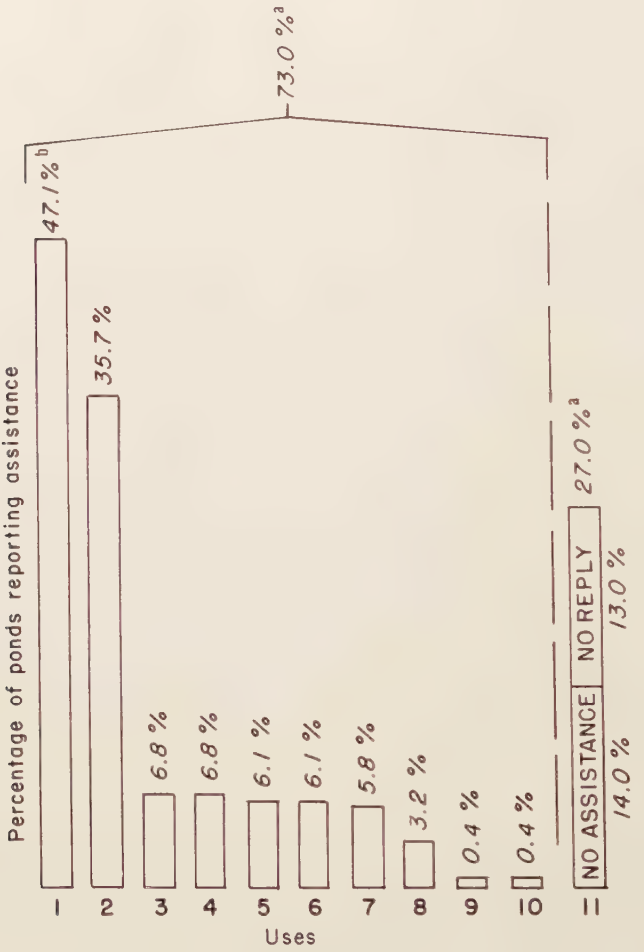

Fig. 7. Sources of assistance by pond owners. Legend: (1) Soil Conservation Service, (2) Agricultural Conservation Program, (3) U. S. Fish and Wildlife Service, (4) bulletins, (5) county Extension agents, (6) private engineers, (7) fish division, Michigan Department of Conservation, (8) from neighbors, (9) Michigan State University, (10) Michigan Water Resources Commission, (11) no assistance and no reply.

(a) Related to the total (278) number of respondents; 73 percent reported assistance from one or more sources; 27 percent reported no assistance or no reply.

(b) Related to the total (278) number of respondents; 47.1 percent of the 278 replies indicated that they had received assistance from the Soil Conservation Service.

TABLE 5—Estimated sources of assistance for design and construction of artificial ponds in Michigan, based upon questionnaire data(a)

Sources of assistance	Number of pond owners
Soil Conservation Service	2,460
Agricultural Conservation Program	1,856
United States Fish and Wildlife Service	356
Bulletins	356
Cooperative Extension Service	318
Private Engineer	318
Fish Division, Michigan Conservation Department	300
Neighbors	148
Michigan State University	19
Michigan Water Resources Commission	19

(a) Questionnaire percent × total number of artificial ponds in Michigan.

Perhaps one of the most significant observations which can be drawn from this analysis is the fact that only 47.1 percent of the total respondents obtained help from the Soil Conservation Service and 35.7 percent received financial assistance from the agricultural program.

The survey of pond owners shows that a very high percentage (94%) of the Michigan ponds are successful, but it must be recognized that the best sites are used first. As more ponds are constructed, more care will be required in their location, design, construction and maintenance.

Technical assistance may be obtained from the following sources: 1. Soil Conservation Service, 2. Fish Division, Michigan Department of Conservation, 3. Extension Service, Michigan State University, 4. Department of Resource Development, Michigan State University, 5. County agricultural agent, 6. From neighbors who have already constructed a pond, 7. Available bulletins, and 8. Registered engineers.

Winter Kill of Fish

Winter kill of fish was a problem on 15 percent of the ponds reported. Another 24 percent failed to respond to this inquiry. Pond design must be slightly modified if desirable fish habitat is to be provided.

Projection of Construction Trends

A projection of trends in 1958 would have been extremely misleading, because the rate of new construction was at its peak in that year. Michigan has now passed through a cycle of intense construction activity and the rate of construction likely will be low for the next few years.

A sustained drought would stimulate considerable interest in pond construction, and destructive frost could cause more farmers to turn to irrigation for frost protection irrigation.

A cycle of high prices for quality truck crops would also have an effect upon the rate of pond construction, but a renewed program of cost sharing by the county Agricultural Stabilization and Conservation Committees would be the most pertinent factor subject to consideration. This factor is unique in that it is not dependent upon the fickle nature of weather or economics; it is the product of voluntary action based upon facts, logical thinking and long range planning.

PRICING CLASS I MILK IN LOWER MICHIGAN

By GLYNN MCBRIDE and ROBERT L. BECK[1]

Department of Agricultural Economics

INTRODUCTION

Pricing of milk for fluid use is one of the most complicated marketing problems faced by milk producers and handlers. Because of the characteristics of the commodity and the conditions under which it is produced and sold, pricing has tended to be largely a local matter. Recent trends in urbanization and new technology in processing, refrigeration, transportation and packaging, however, suggest that many factors may have relevance in considering pricing provisions of federal orders.

A general objective of this study was to set forth the economic rationale commonly used in devising formulas for establishing Class I prices under federal market orders. A specific objective was to examine the formula now being used in the Southern Michigan marketing area and to test an alternative method which might be used in establishing prices for Class I milk under the order.

Economic Rationale Of Formula Pricing

Most federal milk orders use the Midwestern type formula in pricing milk. Under this method, Class I prices are set at specified levels above manufacturing milk prices. The basic formula is derived by computing the value of specified dairy products manufactured from the milk or by using the prices paid by condenseries for whole milk. The manufacturing milk prices are those paid in the open market and are not subject to regulation by federal orders.

[1]The authors acknowledge the assistance of the Board of Directors and manager of Michigan Milk Producers Association and George Irvine, Market Administrator for the Southern Michigan Marketing area and all the officials who arranged the financing of this study under a special grant to Michgan State University. The help and suggestions of colleagues in the Department of Agricultural Economics also are acknowledged.

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The line of reasoning used in basing Class I prices on manufacturing milk prices assumes that the major use to which milk is put, in the area in question, is the manufacturing of dairy products. Supplies for fluid use are diverted from their normal outlets by providing a premium over manufacturing prices in an amount sufficient to overcome the extra costs involved in producing fluid milk. This also assumes that alternative opportunities for use of resources are not generally available.

Another system of formula pricing is commonly referred to as the "Boston" or "economic type" formula.

The economic rationale upon which this type of formula is based assumes that production of milk for manufacturing purposes is not the major competitor for resources. In this case, non-farm jobs and the production of other farm products would also compete for resources.

Under these circumstances, resources used in the production of fluid milk must receive returns comparable with those which they could earn in industry or in producing other farm products. In order to do this, milk prices are geared to the movements in production costs, some indicator of the general price level, and consumer demand as measured by incomes.

Considerations In Developing A Pricing Formula

To have any chance of successful operation, a formula must be based upon the special economic conditions of the area or market in which it is to be used.[2] When the use of an economic type formula is being considered, special account must be taken of the degree to which cash crop and other livestock enterprises provide alternative opportunities for use of land and capital resources. In addition, the availability of non-farm job opportunities as a competitor for the labor resource is of importance.

If conditions in the area appear to be such that the economic rationale used in devising economic formulas is applicable, the next problem involves the selection of indexes and price quotations which might be appropriate as measures of the variables considered most important.

Certain requirements regarding reliability and representativeness would be considered necessary. In addition, the availability of the

[2]See Harris, E. S. and I. R. Hedges, (December, 1948). Formula pricing of milk for fluid use, Farm Credit Adm., Misc. Report 127.

index from the standpoint of time and frequency of release would be taken into account. It is to be remembered that an index is used as an indicator of a factor which is considered important in reflecting change or movement in a variable upon which the formula is based.

Federal Order 24

Federal order No. 24, for the Southern Michigan marketing area, has used a "Midwestern type" formula for pricing fluid milk since its inception in 1951.[3] Alternative methods of computing the basic formula price include a butter-powder formula, the Midwestern condensery series and prices paid by local manufacturing plants.

An average annual differential of $1.43 is added to the basic formula price in arriving at the Class I price. In addition, a supply-demand adjuster, designed to lower or raise the differential in accordance with supplies in relation to Class I sales is used.

Since 1956, however, Class I prices in Michigan have been set through negotiations between the Michigan Milk Producers Association and the milk dealers. These prices have averaged substantially above the minimum prices as computed on the basis of the federal order provisions.

In addition, the number of producers of milk for manufacturing purposes and the volume of milk produced has experienced a steady decline over the past several years. A study conducted in 1955 and again in 1957 indicated that the supply of milk for these purposes had decreased at a rate of about 14 percent per year in the two-year period.[4] Furthermore, circumstances pointed to a continuation of this trend.

Also, during the past decade many structural changes in the economic environment in which manufacturing plants operate have occurred. These changes are reflected primarily in the number of plants operating and size of operations.

These and perhaps other factors suggest an appraisal of the pricing system now being used. Since the prices computed under the order provisions have not been the effective prices for a number of years, is the formula at fault? Is the Class I differential over the basic formula of the correct magnitude? Is the implicit assumption upon which Midwestern formula pricing is based, that milk is produced

[3]This was called the Detroit marketing area until its expansion in February, 1960 to include most of lower Michigan.

[4]McBride, Glynn, and W. H. Blanchard (1959). Changes in Michigan's manufacturing milk industry, Mich. Agr. Expt. Sta., Spec. Bul. 429. 30 pp.

primarily for manufacturing purposes with only a problem of diverting to fluid uses involved, soundly conceived at the present time? Is the industrial and urbanized nature of Michigan such that the alternative uses of labor and land resources are more closely tied to non-farm jobs and the production of other crops than to the production of milk for manufacturing purposes?

These questions are posed for consideration and not with the idea that answers would be given in this study. Rather, the fact that they can reasonably be posed may provide some justification for an examination of the feasibility of the use of an economic type formula in Order 24. The remainder of the study will be devoted to this examination.

Construction Of A Formula

Actual construction of a formula involves the selection and testing of variables which are thought to have influenced milk price movements in the past. The assumption that these influences will continue to operate in about the same way in the future as they have in the past is implicit in their selection. In addition, it is necessary to select an appropriate time period over which relatonships would be consdered. Also, a base period, necessary in the construction of index numbers, and prices with which the prices computed by the formula can be compared, are needed.

In selecting a base period, consideration should be given to its relationship in time to the present. If a period too far in the past or too close to the present is selected many changes, such as technological improvements, cost-price relationships, etc., may not be properly reflected. The most recent "normal" period is considered desirable. It was decided that the period 1947-49 would be used as the base period.

Since our primary concern in this study is with prices paid for fluid milk, the Class I prices actually paid by handlers in the Detroit market were assumed to be the logical variable to be explained. The objective, therefore, is to devise a formula which could be used in computing prices as closely as possible to those actually paid.[5] The Class I prices during the 1935-1960 period included prices paid by handlers prior to the inception of Federal Order No. 24 in 1951, the Federal Order prices from 1951 to April, 1956, and super pool prices from 1956 to 1960. These prices are shown in Table 1.

[5]These prices are used as a bench mark or guide. Their economic "correctness" is not examined here.

TABLE 1—Minimum class I prices paid by handlers for 3.5 percent milk, f.o.b. marketing area, Detroit milk marketing area, 1935-1960

(Dollars per cwt.)		(Dollars per cwt.)	
Year	Annual average price	Year	Annual average price
1935	2.45	1948	5.21
1936	2.48	1949	4.64
1937	2.48	1950	4.23
1938	2.04	1951	5.03
1939	1.90	1952	5.25
1940	2.08	1953	4.67
1941	2.38	1954	4.29
1942	3.00	1955	4.38
1943	3.36	1956	4.98
1944	3.66	1957	4.95
1945	3.69	1958	4.69
1946	4.22	1959	4.66
1947	4.74	1960	4.95

Source: Prices for 1935-1949 are from "History, deliveries and sales of milk," prepared by Michigan Milk Producers Association, agricultural economics mimeo, Vol. 28. Prices for 1950 to September, 1951 are from monthly issues of the *Michigan Milk Messenger*. Prices from September, 1951, to April, 1956 are from the *Marketing Administrators Bulletin*, Detroit marketing area. Prices from April, 1956, through 1960 are prices negotiated by MMPA and the handlers and reported in the *Michigan Milk Messenger* for applicable periods.

Factors To Be Included In The Formula

The next step involves the selection of economic factors which might be included in the formula. These, to be meaningful, must be factors which exert an influence upon the Class I price.

An economic analysis of the market would bring out a large number of factors which influence the price of fluid milk in varying degrees. The problem then becomes one of selecting those which exert the greatest influence. This is necessary from the standpoint of greater simplicity and ease of handling. It would not be feasible to attempt to incorporate all variables which exert some influence on milk prices even if they could be isolated.

Since milk prices tend to move in the same direction as the general price level in the national economy, it seems logical that some indicator of this factor be included. One of the best measures of this level is the Index of U. S. Wholesale Prices.

This index meets other criteria which have been set forth regarding dependability, reliability, representativeness, and timeliness of publication. Its movement, together with the movement of Class I prices received by producers in the Detroit market, is shown in Fig. 1.

Another factor which exerts an influence upon the milk price level in a given area is the consumers' ability to buy or consumer demand with respect to income. A measure of this factor would serve to reflect influences unique in a particular market.

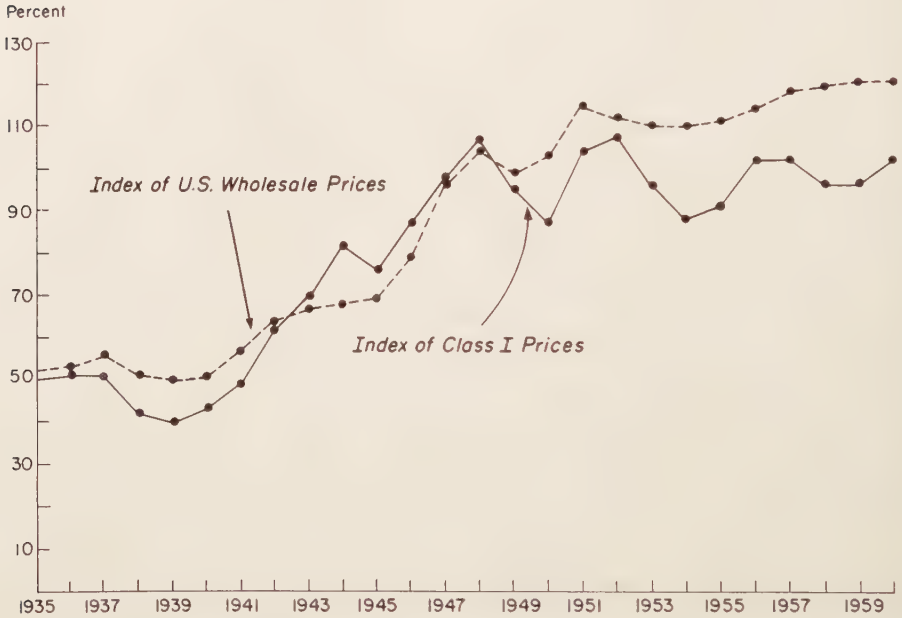

Fig. 1. Index of Class I prices paid for milk in the Detroit, Michigan marketing area and index of U. S. wholesale prices, 1935-60. (1947-49 = 100)

Source: Index of U. S. wholesale prices from the Federal Reserve Bulletin, Board of Governors, Federal Reserve System, Washington, D. C., for the applicable periods. Index of Class I prices computed from data in Table 1.

One measure used very frequently to reflect this influence in a price formula is per capita income. Another measure which might reflect this influence is the percentage of total milk received that is utilized in Class I sales in the market. After some experimentation, it was decided that the latter would be used. An index of utilization in Class I sales and Class I prices paid by handlers in the Detroit market are shown in Fig. 2.

These two measures, index of U. S. wholesale prices and index of Class I sales, reflect influences coming from the demand side. Since the actual price level at any given time is a reflection of influences coming from both the demand and supply side, it appears logical that factors reflecting changes in costs of producing milk be included.

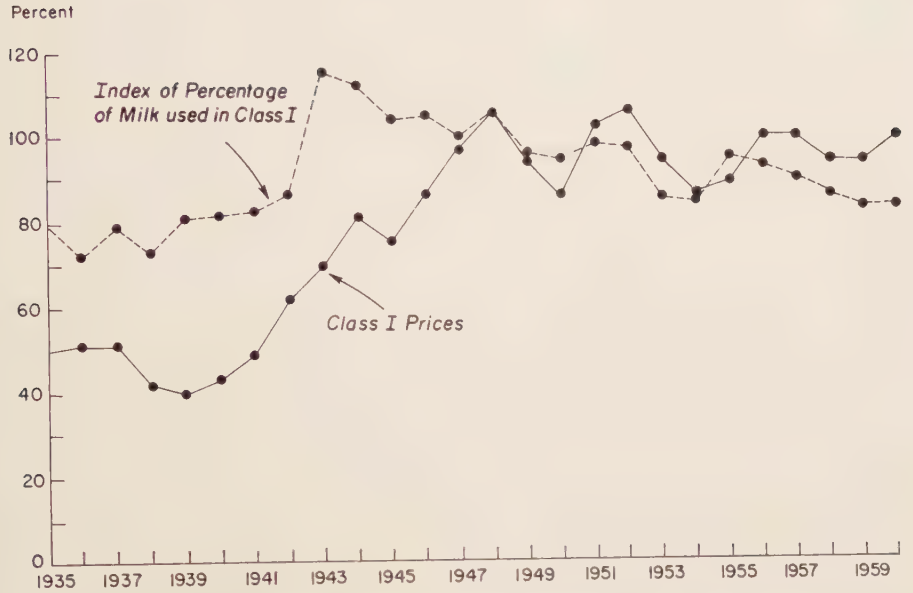

Fig. 2. Index of Class I prices paid for milk in Detroit milk marketing area and index of percentage of milk used in Class I, 1935-60. (1947-49 = 100)

Source: Index of percentage of milk used in Class I from 1935 through 1949 computed from data in History, Deliveries and Sales of Milk, Detroit, Michigan, prepared by M.M.P.A. From 1950 to September 1951, this was computed from data published in the Michigan Milk Messenger. From September 1951 through 1960, computations were made from data published in the Market Administrator's Bulletin. Class I prices index computed from data in Table 1.

Costs of roughage and concentrates make up a large share of the farmer's costs in producing milk. Labor constitutes a large part of the remaining costs. Since it is not practical to attempt to use all cost items, these were combined into a feed-labor index and used as a variable reflecting cost of production or the supply side. This index, together with Class I prices received, is shown in Fig. 3.

A measure of costs is the income which is foregone when resources are used in producing milk rather than other products for which the resources could have been used. This suggests that some measure of prices for Michigan farm products other than dairy be included as a variable.

Data are available for computing an index of this type which is shown in Fig. 4.

Finally, to the extent to which conditions in the marketing area are not in complete accord with the economic rationale set forth for using economic type formulas, some relationship with manufacturing

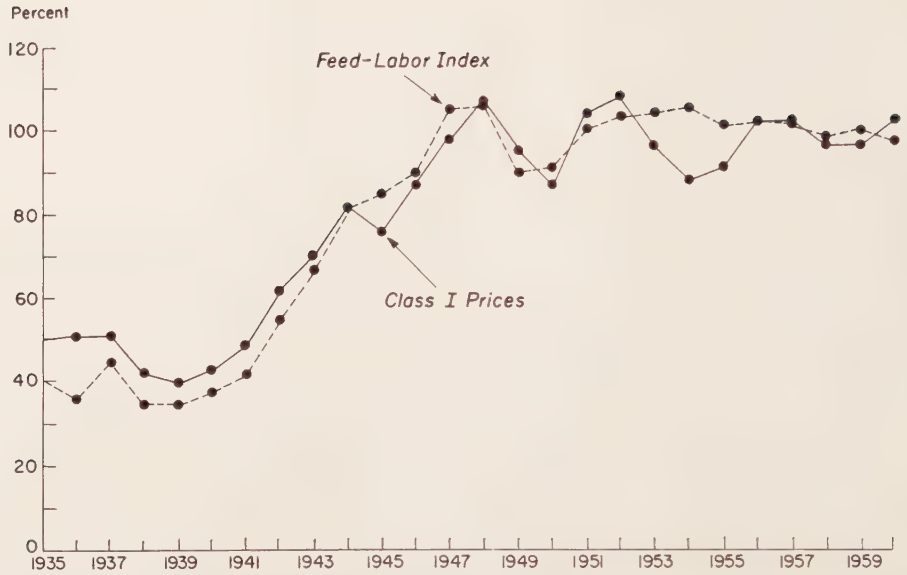

Fig. 3. Index of Class I prices paid for milk in Detroit milk marketing area and index of feed-labor costs of milk production, Michigan, 1935-60. (1947-49 = 100)

Source: Index of Class I prices computed from data in Table 1. For explanation of computing Feed-Labor index, see appendix.

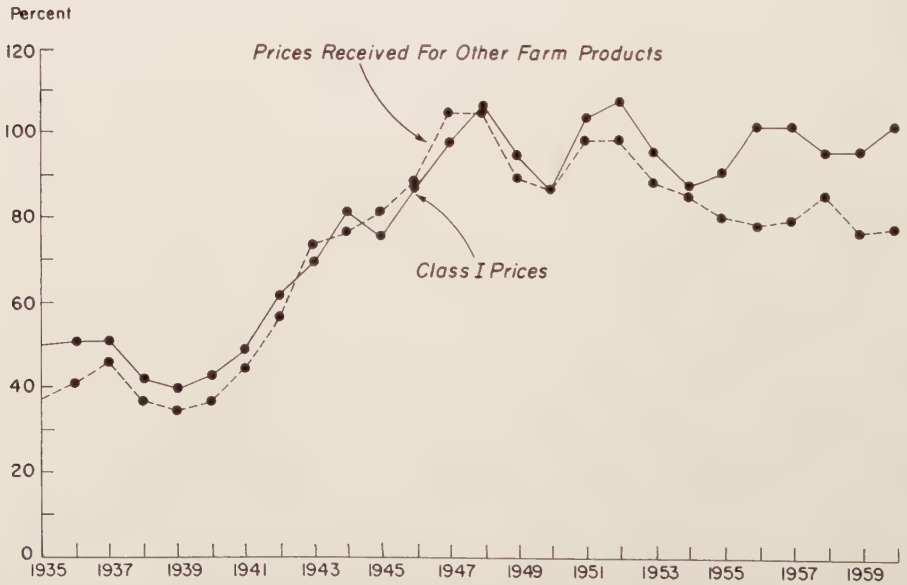

Fig. 4. Index of Class I prices paid for milk in Detroit milk marketing area and index of prices received for all farm products except dairy—Michigan, 1935-60. (1947-49 = 100)

Source: Index of prices received by farmers for all farm products except dairy computed from price series data compiled regularly in agricultural economics department. Class I prices index computed from data in Table 1.

milk prices must exist. To provide this link with the residual use to which fluid milk must be put, an index of average prices paid for milk by Midwestern condenseries is included in the formula.

The data for computing this index are readily available. Figure 5 shows this index plotted with the index of Class I prices paid for milk in the Detroit marketing area.

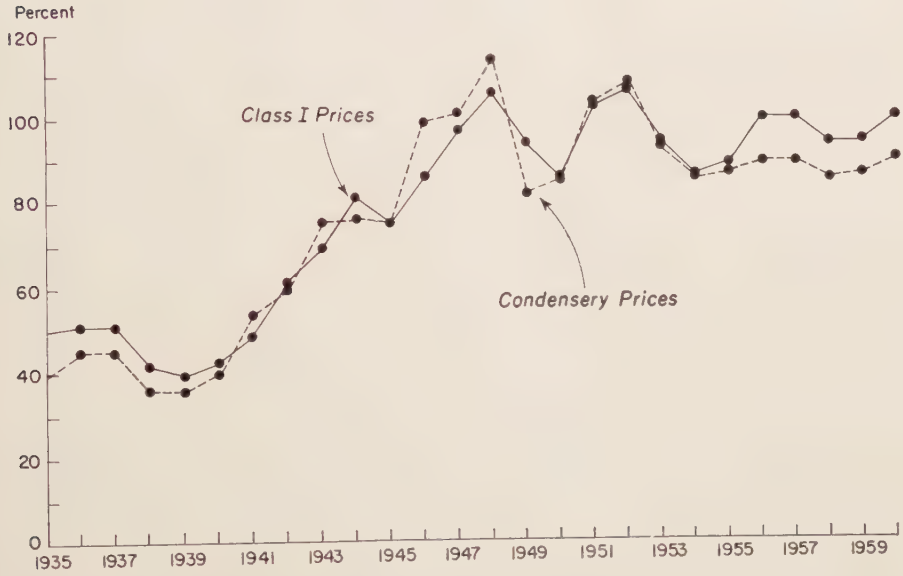

Fig. 5. Index of Class I prices paid for milk in Detroit marketing area and index of prices paid for milk by Midwest Condenseries, 1935-60. (1947-49 = 100)

Source: Index of condensery prices computed from data from applicable issues of Evaporated Condensed and Dry Milk Report, U.S.D.A., A.M.S. Crop Reporting Board. Index of Class I prices computed from data in Table 1.

The dependent variable, Class I milk prices and the independent variables, U. S. wholesale prices, Class I utilization of milk, feed-labor index, index of prices received for farm products except dairy and the index of prices paid by Midwestern condenseries, are shown in Table 2.

Testing The Formula

One method of testing the formula is to assign weights to the various independent factors, make the computations and compare the

resulting prices with those which prevailed during the time period under study. This is known as the graphic method.[6]

Care and judgment must be used in assigning weights to the variables and experimentation with various weights is usually necessary. This method, however, is easy to understand and to use. It is the type most commonly found in orders currently using economic type formulas.

Table 3 shows a comparison between the actual prices during the time period under study and the prices computed by the graphic method. The formula price ranged from 121.0 percent of the actual price in 1939 to 96.3 percent in 1949.

[6]This term is used by Harnes, et al. (November, 1959). *A formula method of pricing fluid milk in Alabama*, Department of Agricultural economics mimeo.

TABLE 2—Index numbers of dependent and independent variables used in the formula

Year	Index of U. S. wholesale prices (1947-49 = 100) X_1	Index of average prices paid for milk by midwest condenseries (1947-49 = 100) X_2	Index of percentage of total milk used in Class I sales in the Detroit marketing area (1947-49 = 100) X_3	Index of feed-labor cost for Michigan (1947-49 = 100) X_4	Index of prices received for all farm products except dairy (1947-49 = 100) X_5	Index of Class I prices paid for milk in the Detroit marketing area (1947-49 = 100) Y
1935.....	52	80	37	39	41	50
1936.....	53	72	41	45	36	51
1937.....	56	79	46	45	45	51
1938.....	51	73	37	36	35	42
1939.....	50	31	35	36	35	70
1940.....	51	82	37	40	38	43
1941.....	57	83	45	54	42	49
1942.....	64	87	57	60	55	62
1943.....	67	116	74	76	67	70
1944.....	68	113	77	77	81	82
1945.....	69	105	82	76	85	76
1946.....	79	106	89	100	90	87
1947.....	96	101	105	102	105	98
1948.....	104	107	105	115	106	107
1949.....	99	92	90	83	90	95
1950.....	103	91	87	86	91	87
1951.....	115	100	99	105	100	104
1952.....	112	99	99	110	103	108
1953.....	110	87	89	94	104	96
1954.....	110	86	86	87	105	88
1955.....	111	97	81	88	101	91
1956.....	114	95	79	91	102	102
1957.....	118	92	80	91	101	102
1958.....	119	88	86	87	98	96
1959.....	120	85	77	88	100	96
1960.....	120	85	78	92	97	102

Source: Sources are indicated in figures shown previously.

TABLE 3—Comparison of prices obtained by the graphic method and actual prices paid for class I milk, Detroit milk marketing area, 1935-60(a) (dollars per cwt., 3.5 percent milk, f.o.b. market)

Year	Graphic index	Graphic price	Actual price	Graphic price as a percentage of actual price
	Number	Dollars	Dollars	
1935	49.70	2.42	2.45	98.8
1936	49.90	2.43	2.48	98.0
1937	54.10	2.63	2.48	106.0
1938	46.80	2.27	2.04	111.3
1939	47.35	2.30	1.90	121.0
1940	49.40	2.40	2.08	115.4
1941	56.25	2.73	2.38	114.7
1942	74.25	3.12	3.00	104.0
1943	77.20	3.75	3.36	111.6
1944	79.85	3.88	3.66	106.0
1945	80.15	3.90	3.69	105.7
1946	90.40	4.39	4.22	104.0
1947	100.65	4.89	4.74	103.2
1948	107.10	5.21	5.21	100.0
1949	92.05	4.47	4.64	96.3
1950	93.55	4.55	4.23	107.6
1951	106.10	5.16	5.03	102.6
1952	106.35	5.17	5.25	98.5
1953	99.30	4.83	4.67	103.4
1954	97.45	4.74	4.29	110.5
1955	98.30	4.78	4.38	109.1
1956	99.50	4.84	4.98	97.2
1957	100.45	4.88	4.95	98.6
1958	99.85	4.85	4.69	103.4
1959	98.90	4.81	4.66	103.2
1960	99.40	4.83	4.95	97.6

(a) The following weights were used:

Index of U. S. wholesale prices	35%
Index of percentage of total milk used in Class I sales	15%
Index of prices received for all farm products except dairy	15%
Index of midwest condensery prices	20%
Feed-labor index for Michigan	15%

The Regression Method

Another method of assigning weights to the variables included in the formula is the regression method. This provides an automatic weighting for each of the independent variables. Table 4 shows the index and formula price as computed by the regression method and comparisons with prices actually paid by handlers during the period under study. The formula price ranged from 90.2 percent to 107.2 percent during 1935 and 1954, respectively.

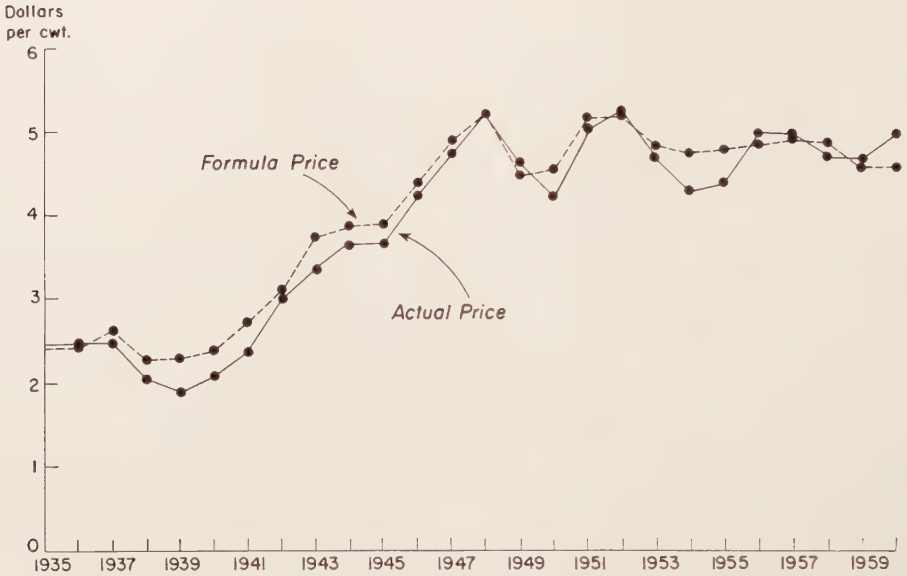

Fig. 6. Actual price of Class I milk and the price as computed by the graphic method. Detroit, Michigan marketing area, 1935-60 (Dollars per cwt. 3.5% milk f.o.b. market).

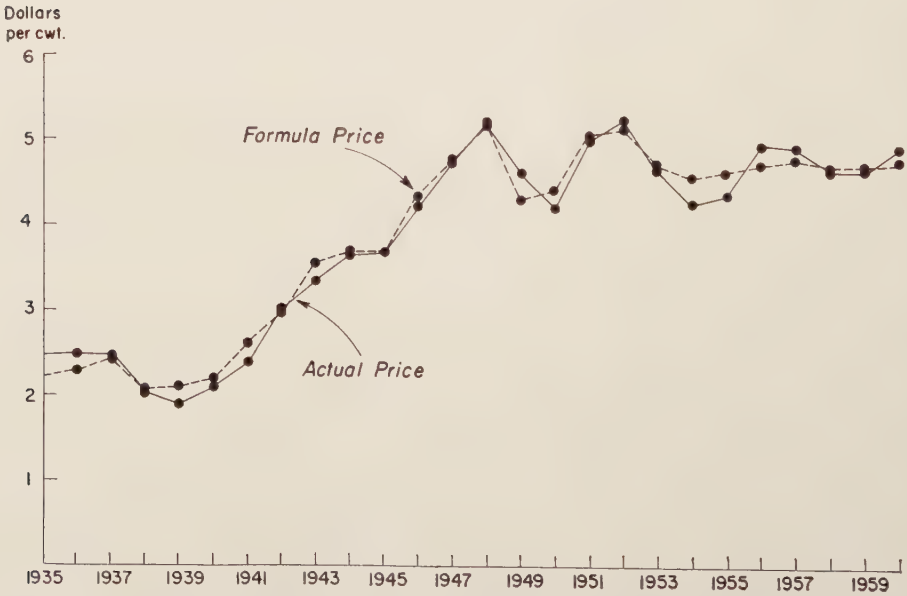

Fig. 7. Actual price of Class I milk and the price computed by the regression method, Detroit, 1935-60 (Dollars per cwt., 3.5% milk f.o.b. market).

TABLE 4—Comparison of formula prices computed by the regression method with actual prices paid by handlers for milk used in class I, Detroit, 1935-1960

Year	X_1 .3477	X_2 .1104	X_3 .0663	X_4 .3677	X_5 .1161	A −2.964	Total index number	Formula price dollars	Actual price dollars	Formula price as a percentage of actual price
1935	18.1	8.8	2.5	14.3	4.8	....	45.5	$2.21	$2.45	90.2
1936	18.4	7.9	2.7	16.5	4.2	....	46.7	2.27	2.48	91.5
1937	19.5	8.7	3.0	16.5	5.2	....	49.9	2.43	2.48	98.0
1938	17.7	8.1	2.5	13.2	4.1	....	42.6	2.07	2.04	101.5
1939	17.4	8.9	2.3	13.2	4.1	....	42.9	2.09	1.90	110.0
1940	17.7	9.0	2.5	14.7	4.4	....	45.3	2.20	2.08	105.8
1941	19.8	9.2	3.0	19.9	4.9	....	53.8	2.62	2.38	110.1
1942	22.3	9.6	3.8	22.1	6.4	....	61.2	2.98	3.00	99.3
1943	23.3	12.8	4.9	27.9	7.8	....	73.7	3.58	3.36	106.5
1944	23.6	12.5	5.1	28.3	9.4	....	75.9	3.69	3.66	100.8
1945	24.0	11.6	5.4	27.9	9.9	....	75.8	3.69	3.69	100.0
1946	27.5	11.8	5.9	36.8	10.5	....	89.5	4.35	4.22	103.1
1947	33.4	11.1	7.0	37.5	12.2	....	98.2	4.77	4.74	100.6
1948	36.2	11.7	7.0	42.3	12.3	....	106.5	5.18	5.21	99.4
1949	34.4	10.2	6.0	30.5	10.5	....	88.6	4.31	4.64	92.9
1950	35.8	10.0	5.8	31.6	10.6	....	90.8	4.42	4.23	104.5
1951	40.0	11.0	6.6	38.6	11.6	....	104.8	5.10	5.03	101.4
1952	38.9	10.9	6.6	40.4	12.0	....	105.8	5.14	5.25	97.9
1953	38.2	9.6	5.9	34.6	12.1	....	97.4	4.74	4.67	101.5
1954	38.2	9.5	5.7	32.0	12.2	....	94.6	4.60	4.29	107.2
1955	38.6	10.7	5.4	32.4	11.7	....	95.8	4.66	4.38	106.4
1956	39.6	10.5	5.2	33.5	11.8	....	97.6	4.75	4.98	95.4
1957	41.0	10.2	5.3	33.5	11.7	....	98.7	4.80	4.95	97.0
1958	41.4	9.7	5.7	32.0	11.4	....	97.2	4.73	4.69	100.9
1959	41.7	9.4	5.1	32.4	11.6	....	97.2	4.73	4.66	101.0
1960	41.7	9.4	5.2	33.8	11.3	....	98.4	4.78	4.95	96.6

X_1: Index of U. S. wholesale prices.
X_2: Index of percentage of total milk used in Class I sales.
X_3: Index of prices received for all farm products except dairy.
X_4: Index of prices paid for manufacturing milk by Midwest condenseries.
X_5: Feed-labor index, Michigan.
A : Y intercept.

CONCLUSIONS

A major conclusion reached as a result of this study is that the use of an economic type formula for pricing milk in Lower Michigan appears feasible.

Additional steps beyond the work done in this study include the provision of flexibility measures, a consideration of the problems relating to contra seasonal movements and the inclusion of measures, perhaps bracketing, to prevent such movements. Also, a base period somewhat closer to the present time should be tested and the use of the index of utilization of milk in Class I sales should be examined. This index may reflect supply as well as demand conditions.

APPENDIX

Summary Of Regression Computations

Model:

$Y = a + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_4 x_4 + b_5 x_5 + u$

Y = Index of Class I price for milk in the Detroit Federal Order market.

X_1 = Index of U. S. wholesale prices.

X_2 = Index of percentage of total milk used in Class I sales in the Detroit market.

X_3 = Index of prices received for all farm products except dairy products, Michigan.

X_4 = Index of prices paid for manufacturing milk by Midwest condenseries.

X_5 = Michigan feed-labor index.

Base period = 1947-49 = 100

Time period = 1935-1960

u = Random error

a = y intercept

Estimated coefficients	Standard error of the coefficients	"t" ratio(*a*)
+.3477	+.1281	+2.713
+.1104	+.1387	+ .796
+.0663	+.1831	+ .362
+.3677	+.1723	+2.134
+.1161	+.1745	+ .665

(*a*) The "t" ratio under the null hypothesis that the estimated coefficient is zero.

$a = -2.964$

Estimated variance (S^2) = 15.468

Standard error of the estimate (S) = 3.933

Explained variation of Y (SSR) = 13230.672

Unexplained variation of Y (SSE) = 309.368

Coefficient of determination (R^2) = .9772
Coefficient of determination adjusted for degrees of freedom ($\bar{R}^2$) = .9714
Number of observations (N) = 26

Resulting formula:

$$Y = -2.964 + .3477\ X_1 + .1104\ X_2 + .0663\ X_3 + .3677\ X_4 + .1161\ X_5$$

Computing A Feed-Labor Index (Michigan)

A. From: "Dairy Cost and Returns in the Detroit Milk Shed" 1945-1951

Cost of Producing 100 Pounds of Milk

Feed	48%
Labor	30%
Other Costs	22%
	100%

Total feed costs are divided as follows: Concentrates = 47%; Roughage = 53%

B. From: **Milk Production,** U.S.D.A., A.M.S., March, 1960

Individual feeds as percentage of the total concentrate ration fed to milk cows in herds kept by dairy reporters, Michigan, 1959.

Corn	53%
Oats	33%
Other Feeds	14%
	100%

Alfalfa and alfalfa-mix hay = 87% of the roughage fed.

C. Weights given to the components of the index based on information in parts A and B

Feed			62%
Concentrates		29%	
corn	18%		
oats	11%		
Roughage (Alfalfa and alfalfa-mix)		33%	
Labor (Farm-wage rates)			38%
			100%

Prices of feed and farm-wage rates used as reported by the Michigan Cooperative Crop Reporting Service, Statistical Reporting Service, U.S.D.A.

JOURNAL ARTICLE ABSTRACTS

Carbohydrate Metabolism of Trichomonads: Growth, Respiration, and Enzyme Activity in Four Species

LINDBLOM, GORDON P.

The Jour. of Protozoology 8(2): 139-150. 1961. (Journal Article 2500 from the Michigan Agricultural Experiment Station)

Growth characteristics were studied on three species of trichomanads, *Trichomonas foetus*, *T. suis* (fecal and nasal forms) of *T. suis and Pentatrichomonas gallinarum*. Acid was produced from glucose by all the organisms, however succinic acid was the major acid produced by *T. foetus*, *P. gallinarum* and the nasal *T. suis*. *T. suis* (fecal) produced more lactic than succinic acid.

Glucose, mannose, fructose and galactose were most active in stimulating respiratory activity but *P. gallinarum* used fructose and galactose more slowly than the other trichomonads.

Iodoacetate was the most potent inhibitor of the aerobic and anaerobic metabolism of all the species studied.

T. suis (fecal) and *P. gallinarum* were found to possess malic dehydrogenase and *P. gallinarum* also showed "malic enzyme" activity.

It was felt that the investigations involving malate and pyruvate would provide a key to the understanding of the complex life processes of these flagellates.

Studies on Bovine Portal Blood II. Blood Flow Determinations with Observations on Hemodilution in the Portal Vein

FRIES, G. F. AND G. H. CONNER

Amer. Jour. of Vet. Res. 22(88): 487-491. 1961. (Journal Article 2520 from the Michigan Agricultural Experiment Station)

Four calves with polyethylene catheters in the portal vein were used to determine the rate of portal blood flow using the indicator dilution technique. T-1824 was used as the indicator. Average flow for 10 determinations in the unanesthetized animal was 37.8 ml min kg with a range from 12.0 to 65.7 ml/min/kg. Flow appeared to be considerably depressed for the first 2 days after establishment of the catheters; and, if these values are excluded, the average was 46.0 ml min kg. Two determinations, made immediately following surgery while the animal was under the effects of anesthesia, were considerably lower than the values from the unanesthetized animal. Deliberately exciting the animal decreased flow from 61.3 to 14.4 ml/min/kg.

The Effect of Phosphorus Fertilization and Time of Application on Chemical Composition of Foliage and on Yield, Sucrose Content and Percent Purity of Sugar Beet Roots

DAVIS, J. F.; GRANT NICHOL AND DON THURLOW

Jour. of the Amer. Soc. of Sugar Beet Tech. XI(5): 406-412. 1961. (Journal Article 2581 from the Michigan Agricultural Experiment Station)

The effect of three rates of planting time 5-20-10 fertilizer (0, 150, and 300 pounds per acre) and phosphate (0, 200, 400, and 800 pounds P_2O_5 per

acre) plowed under prior to planting of sugar beets was investigated on a Kawkawlin loam soil. The 5-20-10 fertilizer increased early growth at all levels of preplanting applied phosphate, increased the phosphorus and potassium contents of plants at blocking time and increased the phosphate content in the petiole of the plant and yield of roots were zero and the 200 pounds of phosphate were plowed under. Percent phosphorus in the tissue decreased as the season progressed where no phosphate had been plowed under. Sucrose content was increased where fertilizer was applied. There was no practical advantage in applying more than 150 pounds of planting time fertilizer, providing there was a rather high level of phosphorus in the soil.

Demand Analysis and Data for Regional and Spatial Models of Adjustment

Bonnen, James T.

Agr. Supply Analysis (Book), Chapter 14: 305 etc. 1961. (Journal Article 2589 from the Michigan Agricultural Experiment Station)

Currently, much research is being focused on the process of adjustment of the agricultural economy or upon the estimation of what actually constitutes the optimum long run economic adjustment for U. S. agriculture. This paper outlines the nature of the long run economic adjustment process, discusses a number of problems involved and types of errors frequently made in designing adjustment research, and indicates some of the data problems and sources. The adaptation of price dependent spatial equilibrium models for long run adjustment analysis is discussed and various types of research design suggested.

Host Ranges and Properties of Some Viruses from Dahlia

Scheffer, R. P. and R. A. Mildner

Phytopathology. 51(6): 372-376. 1961. (Journal Article 2600 from the Michigan Agricultural Experiment Station)

Sixteen plant species were tested as hosts for five virus isolates from dahlias with leaves that showed ringspots. Two isolates caused ringspots on dahlia seedlings; the others caused non-distinctive symptoms. Thermal inactivation points ranged from 40° to 90° C; dilution end points from 1:10 to 1:1200; resistance to aging *in vitro* from 8 to 480 hours; and resistance to aging in drying leaves from 48 to 720 hours. Two of the isolates were considered to be strains of tomato spotted wilt virus, while the other isolates were not identified with known viruses. One of the unknowns caused ringspots on dahlia leaves.

Effects of Gibberellin A_3 on the Chemical Composition of Celery Plants

Sell, H. M.; M. J. Bukovac; S. H. Wittwer and K. P. Hellman

Jour. of Food Sci. 26(3): 209-211. 1961. (Journal Article 2612 from the Michigan Agricultural Experiment Station)

Detailed studies of the composition of celery plants treated with gibberellin revealed that even though marked increases in yield of dry matter may be induced, there were no associated deleterius changes in composition of either the tops or roots. The most significant differences attributed to gibberellin treatment were an increase in non-reducing sugars in the tops and roots, an increase in the calcium content of the tops, and decreases in the nitrate nitrogen, boron, phosphorus, and copper in the tops.

Lipide Distribution in Egg Yolk Lipoprotein Complexes

EVANS, ROBERT JOHN AND SELMA L. BANDEMER

Poultry Science XL(3): 597-603. 1961. (Journal Article 2613 from the Michigan Agricultural Experiment Station)

Egg yolk contains two lipoprotein complexes, lipovitellin and lipovitellenin. These were isolated and lyophilized. The lightly-bound lipides were extracted with petroleum ether and the firmly-bound ones with ethanol. Lipides were separated into neutral fats, phosphatidyl choline, and phosphatidyl ethanolamine by chromatography on silicic acid. Fatty acids of each lipide were determined by gas-liquid chromatography.

Lipovitellin contained 47.5 percent of the total egg yolk protein and 6.8 percent of the lipide. Lipovitellenin contained 38.6 percent of the protein and 93.2 percent of the lipide. The lipovitellin preparation contained 21.7 percent lipides, mostly firmly-bound, and the lipovitellenin, 82 percent, mostly lightly-bound. The lightly-bound lipide fraction was nearly all neutral fat. The firmly-bound lipide of lipovitellin was principaly phosphatidyl choline and of lipovitellenin phosphatidyl ethanolamine.

Neutral fats contained mainly palmitic and oleic acids, phosphatidyl choline mostly palmitic with smaller amounts of stearic and oleic acids, and phosphatidyl ethanolamine palmitic, stearic, and oleic acids.

The Significance of Leptospiral Hemolysin in the Pathogenesis of *Leptospira Pomona* Infections

BAUER, D. C.; L. N. EAMES; S. D. SLEIGHT AND L. C. FERGUSON

Jour. of Infectious Diseases. 108: 229-236. 1961. (Journal Article 2650 from the Michigan Agricultural Experiment Station)

An investigation of the effect of leptospiral hemolysin on newborn lambs was undertaken. The hemolysin was found to be precipitable from culture filtrates of *Leptospira pomona* by ammonium sulfate at 35 percent saturation. Concentration of the precipitated and partially purified hemolysin was followed by injection of this material intravenously into 1 to 4 week old lambs. Icterus, hemoglobinuria and anemia were observed. Lambs with circulating agglutinins to *L. pomona* were not affected by the hemolysin. *In vitro* studies indicated that the effect of antiserum was evident only if in contact with the hemolysin before the addition of erythrocytes. The effect of various incubation temperatures were also investigated. The significance of the findings in relation to the pathogenesis of *L. pomona* infections is discussed.

A Histological Method for Evaluating Tissue Structures from Muscles of Frozen Poultry

MACNEIL, J. H., PATRICIA POOLE AND L. E. DAWSON

Poultry Science. XL(3): 704-717. 1961. (Journal Article 2662 from the Michigan Agricultural Experiment Station)

The study of poultry tissues after the birds have been frozen in a liquid presents special problems in using standard techniques. Several different methods for making histological sections of frozen poultry muscles were evaluated. Photomicrographs were taken of sections prepared under the various methods. Dis-

tinct differences (due to method) were noted in tissue structure indicating the importance of selecting a specific method which can be adopted to a particular problem.

A simple method of frozen fixation was developed using a combination of formalin and alcohol which was maintained at temperatures below freezing. After fixing in this manner the standard procedures of embedding, sectioning and staining were followed.

Bacteria Associated with Cut Flower Containers

Ford, H. E.; D. T. Clark and R. F. Stinson

Proc. of the Amer. Soc. for Hort. Sci. 77: 635-636. 1961. (Journal Article 2667 from the Michigan Agricultural Experiment Station)

Twenty samples were taken from the inner surfaces of containers holding various kinds of cut flowers from four wholesale distributors in Detroit, Michigan. These samples were cultured and representative bacterial colonies were isolated and identified. Nineteen species were present. Those most frequently found were from the following genera: Achromobacter, Bacillus, Micrococcus, and Pseudomonas.

Comparison of the Flotation of *Mastastrongylus* and *Ascaris* Eggs in Three Different Levitation Solutions

Bello, Thomas R.

Amer. Jour. of Vet. Res. 22(88): 597-600. 1961. (Journal Article 2670 from the Michigan Agricultural Experiment Station)

Experiments were performed to determine the relative flotation ability of $MgSO_4$, sucrose and NaCl solutions at Sp. G. 1.200 for the recovery of *Metastrongylus* and *Ascaris* eggs from swine feces. A modification of the method used by Dunn, Gentles, and White (1955) was employed.

It was found that the NaCl solution was ineffective for the diagnosis of *Metastrongylus* eggs, and certain physical characteristics of the medium itself made it least desirable for the recovery of *Ascaris* eggs.

Sucrose solution recovered the highest number of *Ascaris* eggs, but was not as good as $MgSO_4$ for Floating *Metastrongylus* eggs. The best agent studied for the levitation of *Metastrongylus* and *Ascaris* eggs was $MgSO_4$ at a Sp. G. of 1.200.

It is suggested that the difference in the number of eggs recovered by the three flotation agents is due to the effects of osmosis or to the differences in the rates of plasmolysis caused by the solutions.

Nature and Causes of Stairway Falls

Miller, J. A. and M. L. Esmay

Transactions of the ASAE. 4(1): 112-114. 1961. (Journal Article 2677 from the Michigan Agricultural Experiment Station)

The prime objective of this study was to supply basic information about the nature and actual causes of home stairway fall accidents. A comprehensive field study of 101 home stairway fall accidents was made through personal inter-

views. Detailed examinations were made of all stairways and information pertaining to apparent cause of fall and contributing factors were obtained from the persons who had fallen.

The following conclusions were arrived at:

1. The slopes of the accident stairways of this study were not different from a representative cross section of stairways.
2. Non-uniformity of treads and risers was considerably greater on the accident stairways than for a representative group as reported by Velz and Hemphill of the University of Michigan.
3. Slipping was reported as being responsible for more than twice as many falls as any other cause.
4. No general class of stairway covering materials or finishes such as rubber mats, linoleum, carpets or varnish was found to decrease the incidence of slipping.
5. Hand rails were present on the portion of the stairway where falls originated in only 28 percent of the falls.

The *In Vivo* Response of *Mycoplasma Gallisepticum* to Deoxycorticosterone Trimethylacetate

PADGETT, GEORGE A. AND D. E. SCHOENHARD

Amer. Jour. of Vet. Res. 22(89): 749-752. 1961. (Journal Article 2680 from the Michigan Agricultural Experiment Station)

Four-month old leghorn cockerels were inoculated intratracheally with 0.5 cc of pooled allantoic fluid containing *Mycoplasma gallisepticum*. Symptoms of chronic respiratory disease appeared 11-14 days postinoculation. Twenty-one days postinoculation approximately 12,000 organisms per mg. of air sac tissue were isolated. Twenty-two and 43 days postinoculation infected and healthy birds were treated with an intramuscular injection of either 12.5 or 15.0 mg. of deoxycorticosterone trimethylacetate (Ciba).

Twenty-one days posttreatment no *M. gallisepticum* were isolated from 44 percent of the infected treated birds; an average of 100 organisms per mg. of tissue was isolated from the remainder. At the same time, *M. gallisepticum* were isolated from 100 percent of the infected nontreated birds; an average of 5,700 organisms per mg. of tissue was isolated.

Forty-one days post-treatment no *M. gallisepticum* were recovered from the infected treated birds; an average of 100 organisms per mg. of tissue was isolated from 6 of the 9 infected, nontreated birds.

Effect of pH and Brine Concentration on Gas Production by a Putrefactive Anaebore (PA) 3679 in Processed Cheese Spread

JAYNES, J. A.; I. J. PFLUG AND L. G. HARMON

Jour. of Dairy Sci. XLIV(7): 1265-1271. 1961. (Journal Article 2686 from the Michigan Agricultural Experiment Station)

The effect of pH and brine concentration on growth as measured by gas production of PA (Putrefactive Anaerobe) 3679 in a processed cheese spread

containing 10 percent skim milk powder was studied at pH levels of 5.2 to 7.0 and brine concentrations of 2.0 to 8.4 percent.

A technique was developed for detecting small amounts of gas production in thermal death time (TDT) cans using a dial-micrometer.

Gas production by PA 3679 in the processed cheese spread was completely inhibited at or below a pH of 5.6. The lag in gas production was greater at pH 6.0 than at pH 7.0.

An increase in brine concentration of the processed cheese spread produced an increase in the lag time for gas production and a decrease in the rate, total amount and duration of gas production. There was no measurable gas production after incubation for 60 days at 37° C.

Air-Layering of *Picea Glauca* and *Pinus Sylvestris*

Feucht, James R.; Donald R. Watson and F. L. S. O'Rourke

Proc. of the Amer. Soc. for Hort. Sci. 77: 578-582. 1961. (Journal Article 2687 from the Michigan Agricultural Experiment Station)

Air-layers were prepared on the lower, middle and top whorls of each species in April, May, June, July and August, 1959. The air-layers at each whorl on *Picea glauca* were injected with 5 ml. of an aqueous solution of one of the following treatments: 0.5 p.p.m. 2,4,5-T, 100 p.p.m. NAA, 100 p.p.m. 4-TNA, 1000 p.p.m. IBA, and distilled water; and *Pinus sylvestris* air-layers were injected with 100 p.p.m. NAA, IBA and 4-TNA, 1000 p.p.m. IPA, and distilled water.

There was no significant difference between treatments or between positions of the air-layers on the trees. A significantly greater number of *Picea glauca* stems rooted, however, when the air-layers were applied at the beginning of May and mean root length was greater on treatments applied at the end of June.

The Effect of Coatings on the Dissolution of Fertilizers and the Uptake of Fertilizer Potassium by Plants

Lawton, Kirk

Agr. & Food Chem. 9(4): 276. 1961. (Journal Article 2688 from the Michigan Agricultural Experiment Station)

Laboratory, greenhouse, and field studies were undertaken to evaluate the effect of coatings on fertilizer granules in reducing dissolution and plant absorption of nutrients under several soil management practices. Coating materials, including vinyl acetate, acrylic resin, was emulsion, paraffin wax, and several combinations thereof, distinctly reduced the solubility of fused potassium phosphates as well as a commercial 5-20-20 fertilizer. Optical examination of fertilizer particles showed that coatings resulted in the filling of large pores and cracks as well as a surface distribution. Injurious effects of seed-fertilizer contact with wheat was alleviated to some degree by coated fertilizer in greenhouse, but a field study with oats showed no specific benefit for coatings. In a field trial of the effect of rainfall and exposure on release of nutrients from topdressed fertilizer, it was found luxury absorption of potassium by alfalfa was reduced by coatings.

Staphylococci in Colby Cheese

WALKER, G. C.; L. G. HARMON AND C. M. STINE

Jour. of Dairy Sci. XLIV(7): 1272-1282. 1961. (Journal Article 2689 from the Michigan Agricultural Experiment Station)

Colby cheese was manufactured from raw milk inoculated with a coagulase positive *Staphylococcus aureus* and from non-inoculated raw milk obtained from cows with sub-clinical mastitis. Staphylococcus and total counts were performed on milk, curd and whey samples taken during the cheesemaking process, and on samples taken at 15-day intervals while the cheese was stored 4 months at 10° C. Coagulase reaction was determined on colonies picked from S-110 medium and on serum prepared from the cheese.

Counts on S-110 medium were 13 to 32 times greater in the curd than in the whey and increased 6.5 to 29 times between cutting and hooping. Maximum numbers of Staphylococci occurred in the curd-when-hooped or in the cheese when 1 day old, after which the population gradually decreased by coagulase positive Staphylococci were recovered throughout the 4-month storage period. Staphylococci naturally present in milk were better adapted to survive the environment of the cheese making and curing process than laboratory cultures of *S. aureus*. There was no correlation between coagulase reactions on serum extracted from the cheese and organism populations enumerated on S-110 medium.

Enzymatic Activities Associated with Cell Wall Preparations from Corn Coleoptiles

KIVILAAN, A.; T. CABRERA BEAMAN AND R. S. BANDURSKI

Plant Physiol. 36(5): 605-610. 1961. (Journal Article 2701 from the Michigan Agricultural Experiment Station)

The cell wall of corn coleoptile prepared in glycerol medium was found to show considerable enzymatic activities as compared with this of soluble protein and particulate matter from the same tissue. UDPG-pyrophosphorylase activity was found to be approximately as high in cell wall as it is in soluble protein, invertase activity even seven times higher, and ATP-ase activity 2 to 3 times higher than in particulate fractions. Inorganic pyrophosphatase and α-glycerophosphatase activities were also found to be associated with cell wall preparations.

No appreciable non-specific adsorption of cytoplasmic enzymes was observed by cell wall preparations under given conditions.

The Effect of Potassium Concentrations in Synthetic Spectrographic Standards on the Intensity Ratios for Certain Other Elements Present: Spark Excitation

BASS, S. T. AND J. SOULATI

Jour. of the A.O.A.C. 44(3): 517-520. 1961. (Journal Article 2703 from the Michigan Agricultural Experiment Station)

The effects of potassium concentration on the intensity ratios for certain elements commonly determined in the spectrographic analysis of plant materials is discussed. Evidence obtained indicates that the level of potassium affects the intensity ratios of elements other than calcium and phosphorus. The effects of potassium on boron, copper, magnesium, and manganese are demonstrated by

the changes observed in the intensity ratios of standards suggested in the first-action A.O.A.C. methods for spark emission spectrographic analyses.

A method for reducing this influence suggests that the samples be first analyzed for potassium with a flame photometer; grouped according to the potassium content, and then analyzed against standards containing comparable concentrations of potassium. This does not completely eliminate the adverse effect, but does reduce the magnitude of variation.

The matrix effect on calcium is discussed with respect to the influence of potassium and the influence of other elements in the synthetic standard.

Accuracy of the Plastic Bead Method of Measuring Solids-not-Fat of Milk under Field Conditions

Lamb, R. C.: L. D. McGilliard and J. R. Brunner

Jour. of Dairy Sci. XLIV(5): 856-861. 1961. (Journal Article 2706 from the Michigan Agricultural Experiment Station)

The plastic bead method of measuring solids-not-fat (SNF) content of milk is a practical test for use by DHIA supervisors in the field. This method can be as accurate under field conditions as in the laboratory. There was no practical difference in accuracy between it and the lactometer method. The mean differences between duplicate readings in the field, between duplicates in the laboratory, and between duplicate readings in the field and the laboratory were .07, .14, and .16 percent SNF, respectively. Correlations between duplicate readings, between methods, and between field and laboratory were .86 or greater.

Effect of Feeding Certain Defined Nutrients on Cellulose Digestion and Volatile Fatty Acid Concentration of the Rumen

Salsbury, R. L.; J. A. Hoefer and R. W. Luecke

Jour. of Dairy Sci. XLIV(6): 1122-1128. 1961. (Journal Article 2733 from the Michigan Agricultural Experiment Station)

A functional approach to the design of a purified ration for ruminants is described. Experiments based upon the use of an *in vitro* method for measuring the cellulose-digesting ability of the rumen microorganisms of steers fed simple combinations of purified nutrients suggest that this approach would be useful in developing a purified ration.

Results indicate that when the ration consisted of only cellulose, starch and urea, a source of amino acids was required to maintain cellulose digestion. Determination of molar concentrations of volatile fatty acids indicated that feeding ground cellulose in addition to hay plus supplement or straw plus supplement lowered the ratio of acetic acid to propionic acid in the rumen.

Capital Formation: Past and Present

Perkins, Maurice and Lawrence Witt

Jour. of Farm Econ. XLIII(2): 333-344. 1961. (Journal Article 2740 from the Michigan Agricultural Experiment Station)

Capital formation in agriculture is of two types — that created through the use of family labor which otherwise would be underemployed, and that requir-

ing cash expenditures. Both types of capital can be utilized to establish capital facilities for direct production on the farm or for the more round-about forms of capital known as infrastructure or social overhead capital.

Several stages or steps in the development from traditional agriculture were distinguished. The first is primarily a subsistence agriculture with a low level of technology. The second step implies full use of natural resources and growth through a rise in the level of technology. In the third stage, the subsistence sector has largely disappeared and agriculture may be termed commercial.

The process of capital formation tends to be less labor and more cash expenditures in the later stages.

Vitamin K in the Nutrition of Mink

TRAVIS, HUGH F.; ROBERT K. RINGER AND PHILIP J. SCHAIBLE

Jour. of Nutr. 74(2): 181-184. 1961. (Journal Article 2743 from the Michigan Agricultural Experiment Station)

Experiments were conducted to ascertain: (1) if normal adult mink require vitamin K; (2) whether dark mink differ in this respect from sapphire mink which contain the Aleutian gene; (3) if sulfaquinoxaline or certain antibiotics affect blood clotting time.

The dietary requirement of normal adult mink was established as being less than 13 milligrams of menadione sodium bisulfite per ton, or 6.5 micrograms per pound, of feed. Practical ranch rations would contain much higher levels of vitamin K activity.

The whole blood prothrombin times of the sapphire mink tested (16.8 ± 0.4 seconds) were similar to those of normal dark mink (17.8 ± 0.4 seconds).

Sulfaquinoxaline fed for 6 to 8 days at the 0.05 percent level or higher significantly increased the whole blood prothrombin clotting times.

Menadione sodium bisulfite fed at levels of 10 grams per ton of food reduced the clotting time of mink fed sulfaquinoxaline at a level of 0.06 percent.

Addition of aureomycin and terramycin at a level of 400 grams per ton of food when fed for 6 to 8 days did not significantly increase whole blood prothrombin times.

Mink fed a semi-purified ration had comparable blood clotting times to those fed a typical ranch ration.

Investigation of the Safety of High Levels of Antioxidants in Mink Food

TRAVIS, HUGH F. AND PHILIP J. SCHAIBLE

National Fur News 35(5): 15. 1961. (Journal Article 2746 from the Michigan Agricultural Experiment Station)

Antioxidants are used in food ingredients for the preservation of fats. The question arose as to whether levels high enough to be toxic to mink would be ingested in the complete food. To decide this, studies were carried out during two growth and two reproduction periods of mink using butylated hydroxytoluene (BHT) and Santoquin at a level 10 times that allowed in feeds by the Food and Drug Administration. If no harmful effects resulted from feeding this excess amount, then amounts of antioxidants more likely to be present in mink foods certainly would be safe.

When compared to the performance of control animals, no significant differences in late growth rate or furring were obtained from feeding the antioxidants. Concerning reproduction, there was a lowered performance during the first year due to influences not related to the diet; during the second year, no detrimental effects from feeding the antioxidants were observed.

These results indicate that there is an ample margin of safety for the antioxidants in growing and furring mink foods. Further research is needed to be certain of the margin of safety for more normal levels of antioxidants on reproduction.

The Oak Skeletonizer, *Buccalatrix ainsliella*, in a Michigan Woodlot

GIBBONS, CHARLES F. AND JAMES W. BUTCHER

Jour. of Econ. Enty. 54(4): 681-684. 1961. (Journal Article 2751 from the Michigan Agricultural Experiment Station)

The life cycle of *Bucculatrix ainsliella* Murt. under lower Michigan conditions is described. The larvae of this insect first mine and then skeletonize the leaves of red oak *Quercus rubra* L. Two generations were observed in both 1959 and 1960. The initiation, duration, and termination of pupation, adult emergence, oviposition, mining, and skeletonizing are discussed.

Rhubarb Root Necrosis: Its Dissemination, Effect on Yield, and Control by Chemical Soil Treatments

MURAKISHI, HARRY H.

Phytopathology. 51(6): 412-413. 1961. (Journal Article 2753 from the Michigan Agricultural Experiment Station)

The rhubarb root necrosis fungus was found in cuttings and in soil taken from around infected plants. Under experimental conditions, the fungus reduced crown size and stalk yield by 50 percent. Soil fumigation with methyl bromide (2 lbs. per 100 sq. ft.) controlled the disease and greatly increased crown size and stalk yield over untreated, naturally-infected soil.

Development and Application of a Simplified Colorimetric Method for Detecting Carriers of Galactosemia

NORDIN, J. H.; R. K. BRETTHAUER AND R. G. HANSEN

Clin. Chim. Acta. 6: 578-580. 1961. (Journal Article 2754 from the Michigan Agricultural Experiment Station)

A simplified, quantitative, colorimetric procedure for detecting the homozygous recessive and the heterozygous conditions in galactosemia has been developed and applied. This method involves the measurement with a colorimeter of reduced TNDPN at 400 mμ. in the presence of uridine diphosphate glucose and uridine diphosphate glucose dehydrogenase. The method has been applied to 4 galactosemic families plus appropriate controls. Average values were 0, 2.4, and 5.2 μmoles UDPG/hr/ml red cells for patients, carriers and normals, respectively. There was no overlapping of values between groups.

A Herd Irritation Index Using the California Mastitis Test on a Herd Basis

DRURY, A. R. AND G. W. REED

Vet. Med. 56: 147-152. 1961. (Journal Article 2756 from the Michigan Agricultural Experiment Station)

The California Mastitis test (CMT) readings are modified whereby a numeral from 0 to 4 is assigned according to the degree of gelling of strict foremilk. The sum of the readings from each quarter of all cows in a herd is ascertained. The total is then divided by the number of cows sampled in the herd. The figure arrived at is a reflection of the shedding of inflammatory cells from the udders and can be used to judge condition of the herd and changes that may be brought about by management.

Over 9,000 CMT readings were compared to findings of direct microscopic examination of incubated milk and many were checked against blood agar plates.

Effect of Heating Starch on Its Digestion by Rumen Microorganisms

SALSBURY, R. L.; J. A. HOEFER AND R. W. LUECKE

Jour. of An. Sci. 20(3): 569-572. 1961. (Journal Article 2775 from the Michigan Agricultural Experiment Station)

In order to obtain an explanation for the alteration of rumen metabolism by cooked concentrates, corn starch, ground corn, and a commercial heated corn were exposed to various heat treatments and the effect of the treatments on the digestion of the readily hydrolyzable dry matter (RHDM) of these materials by rumen microorganisms was examined. Results were in keeping with the concept that the application of moist heat to starch or starchy feeds brings about hydration of the starch and that hydrated starch is digested more rapidly by rumen microorganisms than untreated starch. Autoclaving ground corn or a commercial heated corn without the addition of water resulted in a decrease in the rate of digestion of their RHDM.

Ribitol and D-Arabitol Utilization by *Aerobacter aerogenes*

WOOD, W. A.; M. J. MCDONOUGH AND L. B. JACOBS

Jour. of Biol. Chem. 236(8): 2190-2195. 1961. (Journal Article 2779 from the Michigan Agricultural Experiment Station)

Growth of *Aerobacter aerogenes* on ribitol induced the formation of a system for oxidation of ribitol and for D-ribulose when adenosine triphosphate was added. Ribitol phosphate was not oxidized. A diphosphopyridine nucleotide-specific ribitol dehydrogenase has been purified 20-fold. The products of ribitol oxidation and D-ribulose reduction have been isolated and identified as D-ribulose and ribitol, respectively. The dehydrogenase was specific for ribitol, D-ribulose and diphosphopyridine nucleotide. The presence of a specific D-ribulokinase, distinct from L-ribulokinase, was demonstrated.

Growth on D-arabitol induced a system for oxidation of D-arabitol and for D-xylulose when adenosine triphosphate was added. D-arabitol dehydrogenase was purified 18-fold and shown to be specific for D-arabitol, D-xylulose and triphosphopyridine nucleotide. The products of D-arabitol oxidation and D-xylulose reduction were isolated and identified as D-xylulose and D-arabitol, respectively. The presence of D-xylulokinase in extracts was demonstrated.

Effect of Electrical Currents on the Transport of Radiocalcium (CA^{45}) in *Phaseolus vulgaris*

ANDERSON, J. R.; S. H. WITTWER AND M. J. BUKOVAC

Physiologia Plantarum. 14:548-553. 1961. (Journal Article 2795 from the Michigan Agricultural Experiment Station)

Radiocalcium applied to the epicotyl tip of bean seedlings subjected to direct current was caused to preferentially migrate into the primary leaf blade to which the anode was attached. This was demonstrated by radio-analysis of dried plant tissues as well as by autoradiography. The electrophoretic plant unit consisted of the negative contact on the tip of one primary leaf and the positive contact on the tip of the opposite primary leaf with the plant tissue extending between. A direct current of 16 to 40 micro-amperes applied for 7 hours was effective in altering the transport of Ca^{45}. Some tissue injury, though very slight, was associated with current levels that greatly altered Ca^{45} transport. Direct current across the plant tissue did not induse basipetal transport of Ca^{45} nor alter its rate of absorption by the foliage.

Pathogenicity of Thielaviopsis Basicola on Peas

LLOYD, A. B. AND JOHN L. LOCKWOOD

Plant Disease Reporter. 45(6): 422-424. 1961. (Journal Article 2798 from the Michigan Agricultural Experiment Station)

In a survey of Michigan pea fields with a root rot in 1960, *Fusarium solani* f. *pisi* was present in all of 19 fields sampled, and *Aphanomyces euteiches* was present in 14 of 25 fields sampled. *Thielaviopsis basicola* was isolated from diseased roots from four of 25 fields sampled. Pathogenicity of 10 isolates of *T. basicola,* based on a scale of increasing disease severity from 0-9, ranged from 1.7-5.5. The most pathogenic isolates caused a black-brown dry rot which completely destroyed the root cortex. In a field at East Lansing with severe root rot, *T. Basicola* appeared to by the principal pathogen.

Fertility of Bull Sperm with Added Catalase

HAFS, H. D.

Jour. of Dairy Sci. XLIV (8): 1529-1536. 1961. (Journal Article No. 2801 from the Michigan Agricultural Experiment Station)

Spermicidal H_2O_2 is formed during metabolism of sperm, but bull sperm contain no catalase – an enzyme which is responsible for detoxification of H_2O_2. This experiment measured the effect of catalase upon the fertility of sperm extended either in Cornell University Extender (CUE) or in a milk extender and used to inseminate 23,837 cows.

CUE resulted in averages of 77.5, 74.8, 68.3, and 69.5 percent 60-90 day non-returns for days 1, 2, 3, and 4 of storage, respectively. The comparable averages for milk were 73.9, 70.1, 65.9, and 56.2 percent; for CUE with catalase were 78.2, 74.0, 69.8, and 68.1 percent; and for milk with catalase were 74.2, 74.9, 69.4, and 61.0 percent.

Failure to detect improvement from catalase in CUE was due to the inherent catalase in the egg yolk of CUE. The improvement from catalase in milk extender was largely attributable to lowered embryonic mortality.

Storage of Fungicide Treated Pea and Cucumber Seeds

deZEEUW, D. J.; R. A. DAVIS AND R. A. CRUM

Plant Disease Reporter. 45(7): 544-547. 1961. (Journal Article 2813 from the Michigan Agricultural Experiment Station)

Pea and cucumber seeds treated with fungicides were stored up to 11 months in sealed jars at room temperature and in the refrigerator. No obvious reduction in germination or vigor of either type of seed resulted from storage. Peas appeared to retain more viability when stored at the lower temperature, but differences were small. No benefit from low temperature storage was found for the cucumber seed. In this work, there was no evidence of increased injury with time of storage of seeds treated with either volatile (Panogen 15) or non-volatile (Elcide 73) mercury seed treatment. The presumed damage to peas by volatile mercury occurred soon after treatment. The non-volatile mercury material gave significantly improved emergence and stand comparable to that provided by thiram (Arasan 75). Cucumber seed tolerated both types of mercury seed treatment equally as well as thiram and protection against damping off was retained for the full storage period at either temperature. All the treatments protected cucumber seedlings against post emergence root damage as shown by green weight of seedlings.

Response of Zinnia Varieties to Tobacco Ringspot Virus

KARAS, J. G.; D. J. deZEEUW AND C. L. HAMNER

Plant Disease Reporter. 45(8): 605-607. 1961. (Journal Article 2821 from the Michigan Agricultural Experiment Station)

Thirty-six accessions of 32 varieties of *Zinnia elegans* (Jacq.) were evaluated for their response to tobacco ringspot virus (TRSV). The varieties differed considerably in respect to agronomic uniformity and their expression of infection. When evaluated by the appearance of mottle, chlorosis, leaf reflexing, leaf puckering, and stunting, the Cupid and Lilliput types appeared most tolerant. The larger types ranged from moderately tolerant to susceptible, although the virus did not produce a necrotic ring pattern and was never lethal. A progressive reduction of mottle and chlorosis, typical of TRSV, was observed in most varieties initially susceptible. One variety, "Persian carpet" (*Zinnia Haageana* (Regel)) was highly resistant.